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VOL. 42 NOVEMBER, 1939 No. 5

CONTENTS

Syphilis of the Skeleton in Early Infancy: The Nonspecificity of Many of the Roentgenographic Changes . . . . . JOHN CAFFEY, M.D. 637
Angiosarcoma of Bone . . . . . HARRY HAUSER, M.D. 656
The Anterior and Posterior "Notch" Shadows Seen in Lateral Roentgenograms of the Vertebrae of Infants . . . . . GEORGE WAGONER, M.D., AND EUGENE P. PENDERGRASS, M.D. 663
Madelung's Deformity . . . . . MAX DANNENBERG, M.D., ... J. I. ANTON, M.D., AND M. B. SPIEGEL, M.D. 671
Three-Phalangeal Thumbs . . . . . S. L. HAAS, M.D. 677
Unilateral Enlargement of the Lower Extremity Accompanying Varicose Veins . . . . . H. I. BIEGELEISEN, M.D. 683
Roentgen Diagnosis of Renal Infection . . . E. L. SHIFLETT, M.D. 689
Effect of Small Stones on Renal Function . . . . . J. ANDREW BOWEN, M.D., AND JAMES R. STITES, M.D. 693
Renal Tuberculosis . . . . . HENRY K. TAYLOR, M.D. 700
Roentgenologic Visualization of the Soft Tissues in Pregnancy . . . . WILLIAM SNOW, M.D., AND MEYER ROSENSOHN, M.D. 709
Roentgenologic Visualization of the Soft Structures of Pregnancy: Experimental Evidence . . . . . SOLOMON WEINTRAUB, M.D., AND WILLIAM SNOW, M.D. 718
Sympus Monopus . . . . . M. H. POPPEL, M.D. 721
Stenosing Esophagitis Associated with Duodenal Ulcer . . . . . I. KLEIN, M.D., AND W. HOCHBAUM, M.D. 724
The Radium Treatment of Angioma in Children . . . . . RALSTON PATERSON, F.R.C.S.(ED), D.M.R.E., AND . . . . . MARGARET C. TOD, F.R.C.S.(ED), F.B.A.R. 726
Irradiation with Small Doses in the Treatment of Functional Gynecological Conditions . . . . . IRA I. KAPLAN, M.D. 731
Local Asphyxia and Roentgen Irradiation of Transplantable Rat Tumors . . . . . FREDERICK M. ALLEN, M.D. 745
The Effect of Heavy Filtration on Skin Tolerance and Depth Dose . . . . RICHARD DRESSER, M.D., AND ADOLPH MELTZER, M.D. 756
A Method of Obtaining Greater Ratio of Deep to Surface Dosage . . . . . S. J. HAWLEY, M.D. 760
Editorials 767
Society Proceedings, Correspondence and News Items 771
Book Reviews 778
Department of Technique
A Roentgenographic Method for the Study of the Second Cervical Vertebra . . . . . HAIG H. KASABACH, M.D. 782
Abstracts of Roentgen and Radium Literature 786

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THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 42 NOVEMBER, 1939 No. 5

SYPHILIS OF THE SKELETON IN EARLY INFANCY

THE NONSPECIFICITY OF MANY OF THE ROENTGENOGRAPHIC CHANGES*

By JOHN CAFFEY, M.D.
NEW YORK CITY

THE high incidence of skeletal involvement in young syphilitic infants has been proved beyond question and the roentgenographic features of these lesions are well known. Hochsinger[11] first reported in 1900 that the osteal changes of congenital syphilis are manifest in roentgenograms. His pioneer observations have been confirmed and elaborated by numerous investigators. Outstanding among these are the contributions of Fraenkel[9] in 1911, of Wimberger[34] in 1925, of Péhu, Policard and Boucomont[23] in 1931, and of McLean[16-19] in 1931.

The specificity of the changes found in syphilitic bones is frequently taken for granted in routine roentgenographic diagnosis although it has never been demonstrated that such changes are limited to syphilitic bones. Moreover, the skeletons of non-syphilitic infants have received relatively little roentgenographic consideration. The ultimate determination of the specificity of the syphilitic lesions must rest on the roentgenographic appraisal of bones from a large number of non-syphilitic infants. We have studied films of the skeletons of 550 young infants, examined during the period 1930–1938, who were syphilis-free as determined by clinical and serological examinations of the infants and the families (when available), with later observations of the patients who survived and some necropsies in those who died. The syphilitic-like changes found in a selected group of these non-syphilitic infants are the subject of this report.

For purposes of clarity we have followed the classification of McLean, who described the panosteitis of early congenital syphilis under the three major divisions: osteochondritis, osteomyelitis and osteoperiostitis.

OSTEOCHONDRITIS

In the skeletal syphilis of the fetus and young infant, changes at the cartilage-shaft junctions predominate and a variety of shadow patterns have been identified in syphilitic osteochondritis:

A. Single thickened transverse lines of increased density at the ends of the shafts produced by an excess of calcified primary cartilage.

B. The thickened transverse shadow of increased density in A plus a contiguous parallel transverse zone of diminished den-

* From the Department of Diseases of Children, College of Physicians and Surgeons, Columbia University and the Babies' Hospital, New York City. Read in summary before the Philadelphia Pediatric Society, November 8, 1938, and at the Fortieth Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 19–22, 1939.

sity on its shaftward margin caused by a deficiency of subchondral bone.

C. Deep zones of diminished density occupying the ends of the shafts, with narrowing and sometimes absence of the terminal transverse shadows, caused by deficiencies in both the subchondral cancellous bone and in the calcified primary cartilage.

D. Double transverse zones of increased density separated by a narrow band of diminished density, or double alternating bands of increased and diminished density produced by a reduplication of B.

E. Serration of the ends of the shafts ("saw-tooth" or "zig-zag" metaphyses) produced by the projections epiphysealward from the primary calcified cartilage of tongues of calcified cartilage, especially around the vessels in the larger cartilage canals.

F. Foci of rarefaction in the angles of the cartilage-shaft junctions caused by focal bone necrosis.

G. Infractions through the osteochondritic zones with impaction and horizontal displacement of fragments.

Lesions Simulating Syphilitic Osteochondritis Found in Non-syphilitic Infants

A. *The Thickened Transverse Shadow Across the Ends of the Shafts.*

Case I. *Syphilitic-like osteochondritis, Type A, in a non-syphilitic infant with bacteriemia due to staphylococcus.* J. C. (544277), a premature infant weighing 2,250 grams, was born in the Sloane Hospital. Syphilis had not been recognized in either parent and serological tests on the maternal blood and physical examination of the mother in the prenatal clinic had not revealed evidence of maternal lues. On the nineteenth day of life roentgenograms of the extremities were normal. On the fortieth day of life, at home, the mother noticed a swelling over the sternal end of the right clavicle at which time also the infant had a poor appetite and was hyperirritable. The patient was admitted to the Babies' Hospital on the forty-third day when blood Kahn tests on both the mother and the infant were negative. No syphilitic manifestations were present in the infant. Aspiration of the mass over the clavicle yielded pus containing *Staphylococcus haemolyticus*, present in direct smears and in culture. Cultures of the blood contained *Staphylococcus haemolyticus* on the forty-third, forty-fourth and forty-fifth days. The mass over the clavicle was incised and drained on the forty-fourth day. The patient died on the forty-sixth day. Necropsy was not performed.

Roentgenograms of the extremities on the forty-third day showed heavy, thickened transverse bands across the ends of the shafts (Fig. 1*A*) identical with the transverse bands seen in syphilitic osteochondritis. Oblique projections of the shoulder girdles showed destruction of the sternal end of the right clavicle.

In view of the repeatedly negative clinical and serological examinations for syphilis in both mother and infant, the chances of the infant having had syphilis seem exceedingly remote. A staphylococcus bacteriemia and staphylococcus osteomyelitis of the clavicle were demonstrated bacteriologically. It seems probable that the roentgen changes at the ends of the diaphyses were caused by this fatal staphyloccous infection. This case is of special significance because the bones had been examined on the nineteenth day of life, before the onset of the staphylococcus infection, and thickened transverse shadows were not then present across the ends of the shafts.

Case II. *Syphilitic-like osteochondritis, Type A, in a non-syphilitic infant with erythroblastosis foetalis.* B. R. (435282) was born prematurely and weighed 2.2 kilograms. There was no known syphilis in the parents. She was admitted to the hospital on the fiftieth day of life with a history of persistent jaundice, enlargement of abdomen and dark urine since the second day of life. Physical examination revealed intense generalized icterus, splenomegaly and pitting edema in the lower abdominal wall and groin.

Laboratory Findings. Blood count: hemoglobin 3.9 gm. per 100 cc. (normal 17.0 grams per 100 cc.), erythrocytes 1.2 million per cu. mm., nucleated erythrocytes 5,100 per cu. mm., leukocytes 18,000 per cu. mm., polymorphonuclears 55 per cent, lymphocytes 36 per cent, myelocytes 85 per cent, myeloblasts 1 per cent, thrombocytes 96,000 per cu. mm., coagulation time, three minutes.

Blood chemistry: dextrose 27 mg. per 100 cc., non-protein nitrogen 47.8 mg. per 100 cc.,

bilirubin 10.3 mg. per 100 cc. Van den Bergh's test, positive (4 plus), direct phase; negative, indirect phase.

Blood serology: the bloods of both infant and mother were negative to the Kahn test.

Roentgenograms of the skeleton taken on the fiftieth day of life showed the heavy transverse lines across the ends of the shafts (Fig. 1*B*).

Two blood transfusions were given, but death occurred forty-eight hours after admission, on the fifty-second day of life.

The diagnosis of syphilis is not tenable in this case in view of the negative serology of the maternal and infantile blood and in view of the fact that all of the other positive findings in this patient can be satisfactorily explained on the basis of erythroblastosis of the newborn with edema, a non-syphilitic condition.

Case III. *Syphilitic-like osteochondritis, Type A, in a non-syphilitic infant with a disorder of nutrition, nature undetermined.* R. M. (423223) was admitted to the hospital at three and three-fourths months of age because she had not gained weight satisfactorily. The gestation and parturition were normal with a birth weight of 7 pounds. She had been nursed at breast for three months and then was given a formula of condensed milk. The infant rarely took more than 2 ounces at a feeding and vomited occasionally. After the first month viosterol, 5 drops daily, and orange juice, 2 teaspoonfuls daily, were taken without difficulty.

Physical examination showed a small malnourished infant weighing 3.0 kilograms which was less than the reported birth weight. The other positive physical findings were generalized waxy pallor and pitting edema of the dorsa of the feet.

Laboratory examination: serum albumin 2.01 gm. per 100 cc., serum globulin 2.66 gm. per 100 cc.

Kahn tests on the bloods of the infant, the mother and the father were negative.

Roentgenograms of the long bones of the extremities presented heavy lines across the ends of the shafts at the cartilage-shaft junctions (Fig. 1*C*).

The presence of syphilis in this patient seems highly improbable in view of the absence of clinical manifestations of the disease and the negative serological findings in the infant, the mother and the father.

A high caloric, high vitamin diet in conjunction with repeated transfusions was given, but the malnutrition persisted and the infant weighed 3.2 kilograms when last examined at five months of age.

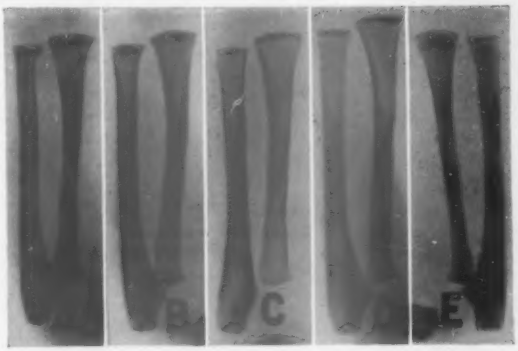

Fig. 1. Syphilitic-like osteochondritis, Type A, in non-syphilitic infants. Note the terminal zones of increased density. *A*, Case I, in an infant forty-three days of age with staphylococcus bacteriemia. *B*, Case II, in an infant fifty days of age with erythroblastosis foetalis. *C*, Case III, in an infant three and three-fourths months of age with a disorder of nutrition, nature undetermined. *D*, Case IV, in an infant three months of age with disseminated hematogenous tuberculosis. *E*, Case V, in an infant thirteen days of age following the administration of bismuth to the syphilitic mother during pregnancy.

Case IV. *Syphilitic-like osteochondritis, Type A, in a non-syphilitic infant with disseminated hematogenous tuberculosis.* J. C. (285551) came under observation at three months of age because "he had always done poorly and had had fever for nine days." The birth was probably premature, as the birth weight was 2.5 kilograms. The mother died of tuberculosis when the patient was two weeks of age.

Marasmus, opisthotonos and enlargement of the head were present. The Mantoux test was positive. Examination of the cerebrospinal fluid showed 280 cells per cu. mm., pellicle formation on standing and numerous tubercle bacilli. Tubercle bacilli were also found in the gastric washings. The blood Kahn test was negative.

In roentgenograms of the long bones heavy transverse lines were present at the cartilage-shaft junctions (Fig. 1*D*). Roentgenograms of the thorax showed changes typical of disseminated miliary tuberculosis and enlarged lobulated shadows in the superior mediastinum.

The patient died one month after admission and four days after the films of Figure 1*D* were

exposed. This patient had tuberculosis and there is no reason to believe that syphilis was also present.

Case v. *Syphilitic-like osteochondritis, Type A, in a non-syphilitic infant following the administration of bismuth to the syphilitic mother during pregnancy.*

The mother of T. M. (448394) was found to have a positive Wassermann reaction in the prenatal clinic. She received ten injections of bismuth containing in all 0.8 gm. of elemental bismuth in two courses between the 143rd and 177th, and the 240th and the 268th days of gestation respectively. Old salvarsan was also given in ten injections totaling 1.35 gm. between the 183rd and the 226th days of pregnancy. The infant was born at term and was under observation for the succeeding twenty-eight months. There were no clinical manifestations of syphilis during this period. Six serological examinations of the blood were negative in the fifth week and in the sixth, ninth, fifteenth, twenty-first and twenty-eighth months.

Roentgenograms of the upper extremities made on the thirteenth day of life showed deep bands of increased density across the distal ends of the radii and ulnae (Fig. 1*E*). In the larger bones of the lower extremities, where growth is more rapid, double transverse zones were present.[3] Later roentgenographic examinations of the skeleton on the fifty-sixth day and at the sixth month showed a gradual fading of these lesions and no roentgen evidence of osteal syphilis was present in these later films.

The possibility of the presence of syphilis in this infant is exceedingly remote. The mother was treated intensively during the last seven lunar months of pregnancy, the infant presented no clinical manifestations of syphilis during the first twenty-eight months of life and repeated serological examinations during the same period were negative. With the exception of the transverse lines in the bones, the skeleton was negative for syphilis at thirteen days, at two months and at six minths of age.

B. *Syphilitic-like Osteochondritis, Type B: the Thickened Transverse Line of Increased Density with Contiguous Parallel Transverse Line of Diminished Density on the Shaftward Margin, in Non-syphilitic Infants.*

Case vi. *In a non-syphilitic infant with erythroblastosis foetalis and hydrops of the newborn.* B. M. (542441) was the daughter of an apparently normal mother whose blood Wassermann reaction was negative. A sister, two years of age, was said to be normal. The pregnancy had been uneventful, the infant being born at term after a normal delivery. The placenta was approximately twice normal size and edematous. Examination at birth showed generalized, severe flaccidity, shallow, irregular respirations, enlarged liver and spleen, small head with a small anterior fontanelle and swellings in the parotid regions. Three hours after birth marked edema, pallor and jaundice developed. A blood count at this time showed an anemia with erythroblastosis; hemoglobin 60 per cent, erythrocytes 1.8 million per cu. mm., leukocytes 21,000 per cu. mm., polymorphonuclears 31 per cent, lymphocytes 60 per cent, reticulocytes 34 per cent, and nucleated erythrocytes 144,000 per cu. mm.

Seven hours after birth 60 cc. of whole blood was given intravenously. The edema and cyanosis continued to increase in severity and the liver and spleen to increase in size until both reached into the pelvis. The patient died approximately fourteen hours after birth with no significant improvement in the blood despite two transfusions of blood. Other laboratory findings of interest were: serum bilirubin 16.7 mg. per 100 cc.; Van den Bergh's test four plus positive direct; serum albumin 3.46 gm. per 100 cc.; serum globulin 2.12 gm. per 100 cc. The blood Kahn test was negative. The clinical diagnosis was erythroblastosis foetalis with hydrops of the newborn.

The findings at necropsy supported the clinical diagnosis and no evidence of syphilis was found. Hemorrhages were present in the cerebellum, in the base of the cerebrum, in the adrenals and in the esophageal and uterine mucosae.

Roentgenograms of the long bones taken in the fourth hour of life are shown in Figure 2*A*. They present deep bands of increased density across the ends of the shafts with narrower zones of diminished density lying parallel along the shaftward margins. These changes are identical with those of syphilitic osteochondritis, Type B. The depth of these lesions suggests that endochondral tissue formation had been interfered with for several days and possibly several weeks prior to birth.

The negative serology in both mother and

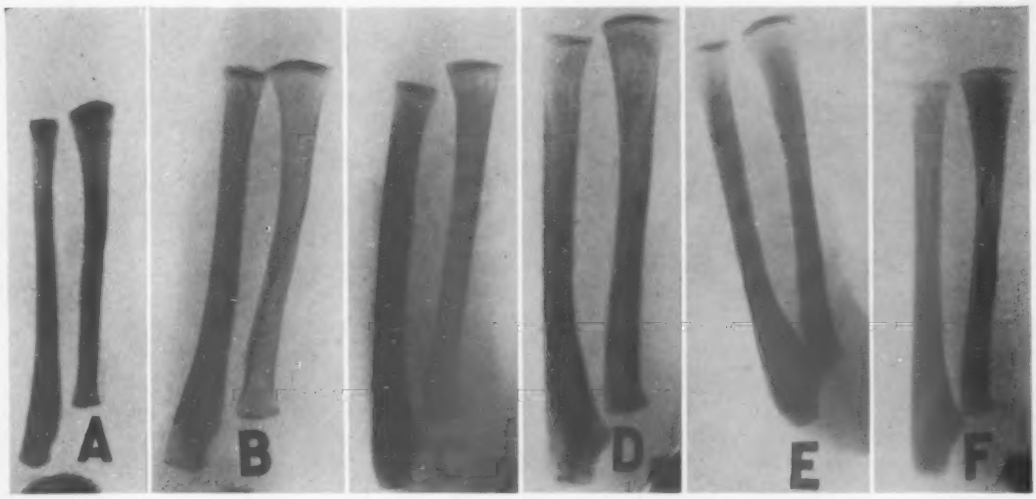

Fig. 2. Syphilitic-like osteochondritis, Type B, in non-syphilitic infants. Note terminal zones of increased density with contiguous parallel zones of diminished density. *A*, Case VI, in an infant four hours after birth with erythroblastosis foetalis and hydrops of the newborn. *B*, Case VII, in an infant sixty days of age with a pneumococcus bacteriemia. *C*, Case VIII, in an infant two months of age with atypical familial hemolytic anemia. *D*, Case IX, in an infant eight weeks of age with transient hemiparesis of the arm and leg, cause undetermined. *E*, Case X, in an infant twenty-five days of age with multiple birth injuries. *F*, Case XI, in an infant sixteen days of age with omphalitis and septic hemolytic anemia of the newborn.

infant and the absence of syphilitic changes in the necropsy leave little justification for a diagnosis of syphilis in this case.

Case VII. *Syphilitic-like osteochondritis, Type B, in a non-syphilitic infant with pneumococcus bacteriemia.* N. S. (318650) developed an upper respiratory infection in the eighth week of life. One week later he was admitted to the hospital with cellulitis of the dorsum of the left hand and right buttock and suppurative arthritis of the left shoulder. Incision and drainage of these regions was followed by rapid recovery. Pneumococcus Type VII was found in the pus from each of these lesions and four blood cultures contained pneumococcus Type VII. There was no known syphilis in the parents and serological tests (Kahn) were negative on the blood of the infant and his mother.

Roentgenograms of the long bones made on the sixtieth day of life showed heavy, transverse lines at the ends of the shafts with zones of diminished density lying contiguous and parallel to them (Fig. 2*B*).

No evidence of syphilis was found in the serological examination of the mother or the infant and the infant had no clinical syphilitic manifestations.

Case VIII. *Syphilitic-like osteochondritis, Type B, in a non-syphilitic infant with atypical familial hemolytic anemia.* H. F. (505102) was born at term. At birth the abdomen appeared enlarged and on the second day jaundice appeared and persisted. "Black and blue" spots appeared on the face and abdomen in the fifth week. One sibling was said to have suffered from typical chronic hemolytic icterus and had improved following a splenectomy done in the fifth year. There was no known syphilis in the parents.

The first physical examination at two months of age disclosed generalized icterus, malnutrition, craniotabes, a greatly enlarged spleen which filled the left abdomen and a liver which extended 4 cm. below the costal margin.

Laboratory examination: hemoglobin 6.73 gm. per 100 cc. (39 per cent), erythrocytes 1.7 million per cu. mm., reticulocytes 2.6 per cent, nucleated erythrocytes 760 per cu. mm., leukocytes 7,600 per cu. mm., polymorphonuclears 37 per cent, lymphocytes 53 per cent, monocytes 8 per cent, myelocytes 1 per cent, myeloblasts 1 per cent, Price-Jones curve, normal.

Fragility of erythrocytes in salt solution: hemolysis began at 0.525 per cent and was complete at 0.325 per cent. In the blood of a normal patient used as a control, hemolysis began at 0.425 per cent and was complete at 0.325 per cent.

Van den Bergh's test was positive in the direct phase. Serum bilirubin was 2.91 mg. per 100 cc. Kahn test was negative.

Roentgenograms of the long bones showed heavy transverse bands across the ends of the shafts with parallel deep zones of diminished density on their shaftward margins similar to the lesions of syphilitic osteochondritis, Type B (Fig. 2*C*). Later roentgenograms at five and a half months presented no syphilitic changes, but transverse lines were present deeper in the shafts.

A splenectomy was done at five and a half months with an excellent clinical result. Sections of the spleen showed myeloid hyperplasia and no syphilitic changes were seen.

Case IX. *Syphilitic-like osteochondritis, Type B, in a non-syphilitic infant with transient hemiparesis of the arm and leg, cause undetermined.* R.B. (535428) was first seen in the eighth week of life with the history of an upper respiratory infection and conjunctivitis which had begun in the sixth week; tenderness, weakness, limitation of motion and swelling of the left leg and tenderness of the left arm had been present for three days. On examination there was no evidence of rhinitis or skin eruption. The left wrist was swollen and tender and the left arm was weak but there was no pain on passive motion. The left leg was held motionless and partially flexed at the knee. Extreme adduction and abduction caused slight pain. The lower border of the spleen was 1 cm. below the costal margin. The temperature was normal during hospital residence of twelve days.

Laboratory examination: Kahn and Wassermann tests on the infant and mother were negative. There were no pathological changes in the cerebrospinal fluid. Three blood cultures were negative and three stool cultures yielded no pathogenic organisms. Agglutination tests with the blood serum were negative with the typhoid-dysentery group, with *B. melitensis* and *B. abortus*.

Roentgenograms of the long bones revealed moderately severe changes similar to those seen in syphilitic osteochondritis, Type B (Fig. 2*D*). There was no evidence of infraction or impaction of the bones in the left extremities, so that the pseudoparalysis on the left was not the syphilitic Parrot type.

During twelve days of hospital residence the clinical manifestations in the left arm and left leg diminished. Reports from the family physician indicate that there was a gradual complete recovery later at home. Roentgenograms at eleven weeks and at six months showed a gradual fading out of the lesions at the cartilage-shaft junctions with residual transverse lines deep in the shafts. No osteomyelitic and no osteoperiostitic changes were seen in the later films.

The complete recovery without antisyphilitic therapy, the negative blood serology of the mother and infant, the disappearance of the roentgen changes in later films, eliminate syphilis as the probable cause of the bone lesions in this patient. A satisfactory diagnosis could not be made.

Case X. *Syphilitic-like osteochondritis, Type B, in a non-syphilitic infant with multiple birth injuries.* M.C. (547996) was delivered by version and extraction after an eight months' gestation. Cyanosis, dyspnea and twitching of the facial muscles began in the first day of life and the anterior fontanelle was noted to have been prominent by the family physician. The head increased rapidly in size during the third week when the infant was admitted to the hospital. The cerebrospinal fluid was reported to have contained large amounts of blood and to have shown increased pressure in five examinations done before hospital admission. Fractures of both humeri were noted at birth and casts were applied to both arms. The infant had continued to be lethargic since birth.

Physical examination on the twentieth day showed an enlarged head, full fontanelle and widened suture lines. Both humeri had lateral bowing in their middle thirds and the left arm was weak.

The cerebrospinal fluid contained considerable amounts of macroscopic blood and had a pressure of 200 mm. of water.

The Kahn test on the blood was negative.

Roentgenograms of the extremities made on the twenty-fifth day of life showed heavy transverse bands across the ends of the shafts with deeper contiguous parallel zones of diminished density (Fig. 2*E*). Complete fractures with angulation deformity and callus formation were present in the humeri.

There were no findings in this case, either clinical or serological, to support a diagnosis of syphilis. The patient died on the fiftieth day of life.

Case XI. *Syphilitic-like osteochondritis, Type B, in a non-syphilitic infant with omphalitis and septic hemolytic anemia of the newborn.* V.C. (423241) was considered normal until the third

day of life when the umbilical stump began to ooze and twenty-four hours later jaundice developed. Physical examination on the fourth day showed generalized icterus, foul omphalitis and an enlarged spleen palpable at the costal margin. Serological tests (Kahn) on the blood of the mother, the father and the infant were negative. One sibling was reported to have died with jaundice on the ninth day of life.

The admission serum bilirubin was 35.7 mg. per 100 cc. and the hemoglobin 17 gm. per 100 cc. (100 per cent). Following a blood transfusion the serum bilirubin increased to 45.4 mg. per 100 cc. and the hemoglobin to 25.5 gm. per 100 cc. (150 per cent). Twelve days later and following two blood transfusions the hemoglobin had decreased to 9.0 gm. per 100 cc. (53 per cent). Normoblasts were seen in blood smears for several days after admission, reaching a peak of 2,800 per cu. mm. on the sixth day of life. On the fifty-first day no normoblasts were seen and the blood bilirubin was 0.83 mg. per 100 cc. *B. coli* grew in cultures from the umbilical stump. Four blood cultures were sterile.

Roentgenograms of the long bones made on the sixteenth day of life showed osteochondritic-like changes, Type B (Fig. 2*F*).

After the tenth day of life there was progressive clearing of the jaundice but signs of spastic quadriplegia developed and continued until the nineteenth month, when death occurred from lobular pneumonia. A second blood Kahn test in the fourteenth month was negative. At necropsy no evidence of syphilis was found, but diffuse cortical degeneration was present in the cerebrum. No evidence of kernicterus was found in the basal nuclei and brain stem, but the absence at nineteen months of the usual microscopic lesions of kernicterus did not, it was felt, absolutely exclude the possibility that the cortical degeneration might have been caused by neonatal jaundice.

c. *Syphilitic-like Osteochondritis, Type C, with Deep Zones of Diminished Density Filling the Ends of the Shafts in Non-syphilitic Infants.*

Case xii. *A non-syphilitic infant with congenital atresia of the biliary apparatus.* L.G. (442865) was considered normal at birth and until the eighth day when, after circumcision, bleeding continued for three days. Following transfusion persistent, generalized jaundice developed. There was no known syphilis in the family. The patient entered the hospital on the thirtieth day of life when he presented generalized jaundice, an enlarged liver (5 cm. below the costal margin) and an enlarged spleen (4.5 cm. below the costal margin). Examination of the blood disclosed a secondary anemia. Van den Bergh's test was strongly positive in the direct phase, the serum bilirubin was 15.0 mg. per 100 cc. Kahn tests performed on the blood of the infant, the mother and the father were negative. A second Kahn test on the infant's blood following the taking of roentgenograms was also negative.

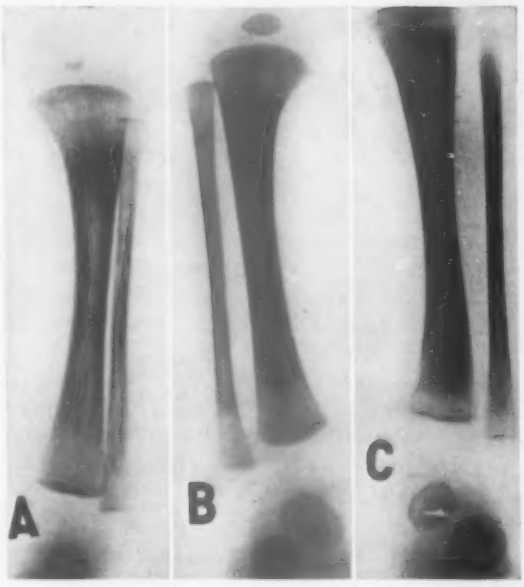

Fig. 3. Syphilitic-like osteochondritis, Type c, in non-syphilitic infants. Note the deep zones of diminished density occupying the ends of the shafts. *A*, Case xii, in an infant thirty days of age with congenital atresia of the biliary apparatus. *B*, Case xiii, in an infant twelve days of age following administration of bismuth to the syphilitic mother during pregnancy. *C*, Case xiv, in an infant fifteen days of age with encephalomyelitis due to a protozoan.

Roentgenograms taken on the thirtieth day of life showed the ends of the shafts to be occupied by deep zones of diminished density (Fig. 3*A*). The terminal transverse lines of the primary cartilage not only showed no increase in density, but appeared to be partially faded out.

The infant died when three and one-half months of age and at necropsy congenital atresia of the common bile duct was found with biliary cirrhosis of the liver. No evidence of syphilis was found.

Case xiii. *Syphilitic-like osteochondritis, Type C, in a non-syphilitic infant following the*

administration of bismuth to the syphilitic mother during pregnancy. The mother of B.T. (403045) had a four plus Wassermann reaction and a syphilitic skin eruption eighteen months preceding this pregnancy. After treatment with arsenic and bismuth the rash disappeared and the Wassermann reaction became negative. During the pregnancy she received nine injections of bismuth in the fourth, fifth and sixth lunar months. The Wassermann reaction was again negative in the seventh lunar month. Ten injections of old salvarsan were given in the seventh, eighth and ninth lunar months.

The patient was born at full term after a normal gestation and there were no clinical manifestations of syphilis in the neonatal period. The cord Wassermann and Wassermann reaction at eleven days were negative.

Roentgenograms of the long bones made on the twelfth day of life revealed deep zones of diminished density occupying the ends of the shafts (Fig. 3*C*), but without any thickening of the primary calcified cartilage at the cartilage-shaft junctions. However, on the shaftward border of the deep zones of diminished density there were heavy transverse lines across the shafts which were probably remnants of the bismuth lines formed earlier by the transmission of bismuth across the placenta during the fourth, fifth and sixth months of fetal life, affecting the primary cartilage at a time when the fetal bones were much shorter than at present. The terminal segments of the shafts which had grown after the formation of the bismuth lines appeared to have a deficient cancellous structure. We have seen this same lesion roentgenographically and anatomically in growing dogs, in the segments of bone which have developed after the formation of bismuth lines.

This patient was under observation for four years and remained free from clinical manifestations of syphilis. Later serological examinations on the thirteenth, twentieth and sixty-seventh days, and at four years and two months were negative.

The antisyphilitic therapy given the mother both before and during the pregnancy with a serological reversal to negative before conception and a persistence of the negative reaction throughout pregnancy makes it highly improbable that spirochetes reached the fetus. The negative clinical and serological results during fifty months offer strong support for the absence of syphilis in this patient. Roentgenographic lesions of this type, of which we have seen 6 similar cases, are common following the bismuth therapy to the pregnant mother.

Case xiv. *Syphilitic-like osteochondritis, Type C, in a non-syphilitic infant with meningoencephalitis due to a protozoan.* C.D. (552107) was delivered by abdominal section because of placenta praevia. The birth weight was 3.0 kilograms. On the third day of life, convulsions occurred and flaccidity and weakness of the lower extremities and abdominal muscles were noted. These signs persisted and on the seventeenth day the clinical picture suggested a lesion of the cervical cord, probably incomplete. The weakness of the lower extremities and abdomen persisted. The patient died on the thirtieth day of life. Gross blood and xanthochromia were found in the cerebrospinal fluid on the sixteenth day.

Serological tests on the mother and infant (twenty-fourth day) were negative.

Necropsy was limited to the central nervous system. The brain and spinal cord showed multiple small granulomata with many large areas of necrosis and contained extracellular, intracellular and encysted forms of a protozoan.[35] No evidence of syphilis was present. Material from these lesions was injected into mice and rabbits and the granulomatous lesions containing protozoans in large numbers were reproduced in these animals.

Roentgenograms on the fifteenth day of life show changes identical with severe syphilitic osteochondritis, Type c (Fig. 3*C*).

d. *Syphilitic-like Osteochondritis, Type D, the Double Zones of Increased and Diminished Density in a Non-syphilitic Infant with Disseminated Hematogenous Tuberculosis.*

Case xv. W.M. (536357) had been exposed to a father with advanced pulmonary tuberculosis. The infant was admitted at three months of age with cough and fever of ten days' duration. Malnutrition, diffuse crepitant râles and an enlarged spleen (3 cm. below the costal margin) were found on physical examination. The Mantoux test was positive in 1:10,000 dilution and tubercle bacilli were recovered from gastric washings. In roentgenograms of the thorax diffuse, fine focal areas of increased density, typical of disseminated hematogenous tuberculosis, were present in the lungs. The Kahn test was negative. The patient died when five months of age.

Roentgenograms of the skeleton were taken on the 96th, 111th, and 143rd days of life. In the two earlier examinations changes much like those of osteochondritis, Type B, were present. In the last examination the terminal segments of the tibiae contained four transverse striations of alternating increased and diminished density (Fig. 4).

COMMENT

The cause of osteochondritis in syphilitic infants has not been determined conclusively and has been debated since the earliest microscopic description of these lesions. Wegner[32] looked upon osteochondritis as an inflammatory lesion, while Parrot[22] concluded that it is nutritional in origin and he defined it as syphilitic dystrophy. Later experience has supported Parrot's contentions and we now know that many of the changes seen in syphilitic osteochondritis may occur following alteration of endochondral bone formation when inflammatory factors are not present.[21] Harris[10] has reported that the relative starvation of breast fed infants in the neonatal period may produce transverse lines in bones and that these do not develop in artifically fed newborn infants who receive adequate feeding from birth and have little or no early "physiological loss of weight." It is noteworthy in our group of non-syphilitic infants that osteochondritic-like changes developed not only in non-syphilitic bacteriemias (due to staphylococcus, pneumococcus, gonococcus, and tubercle bacillus) where inflammation might have been a factor in their genesis, but also in a variety of conditions where inflammatory reactions in the bones probably played no part, such as in erythroblastosis foetalis, malnutrition, birth injuries, familial hemolytic icterus and after maternal bismuth therapy. Osteochondritis may be a misnomer for many of these lesions at the cartilage-shaft junctions and there is much to support the designation of osteochondrosis, since this term does not imply the presence of inflammation.

Vogt[31] concluded after a roentgenographic study of infantile bone syphilis that osteochondritis, Type A, is not diagnostic of lues, but that it is a disturbance of bone growth which may be caused by any severe nutritional disturbance. He considered osteochondritis, Type B, to be very suggestive of syphilis and the serrated metaphyses, Type E, highly characteristic.

FIG. 4. Syphilitic-like osteochondritis, Type D, in a non-syphilitic infant four and a half months of age with disseminated hematogenous tuberculosis (Case XV). Note the double zones of increased and diminished density across the ends of the shafts.

Péhu, Policard and Boucomont[23] emphasized that our ideas on the specificity of bone lesions must be broadened and quote Stettner of Erlangen as to the prudence which must be used in the interpretation of osteochondritis since this type of lesion can be caused by indeterminate factors which affect the nutrition of the fetus.

Wimberger[34] found difficulty in differentiating syphilitic osteochondritis, Type A, from mild rickets in the healing stage when the primary calcified cartilage is thickened and he mentions the value of diffuse osteoporosis of the shaft as an aid in identifying rachitic bones.

More recently a nonspecific osteochondritis resembling syphilitic osteochondritis has been described by Priesel and Siegl[26]

in young infants with septic infections. Epstein and Klein[8] likewise have found "typical syphilitic bone changes" in 8 non-syphilitic infants. Four of these patients had lesions resembling osteochondritis, Types A and B, during the course of bacteriemia with polyarthritis and multiple cellulitis.

Osteochondritic-like changes have been described recently[3] in non-syphilitic newborn infants whose syphilitic mothers received bismuth during pregnancy. It seems probable that the ends of the fetal bones are frequently changed by maternal bismuth therapy and that these bismuth lesions cannot be always differentiated from syphilitic osteochondritis (see Cases V and XIII). Christie[4] has proved that such changes following the administration of bismuth are not due to healed syphilitic fetal osteochondritis, since he found transverse lines in the newborn following the administration of bismuth to non-syphilitic pregnant women where the syphilitic factor was not present. Kato[14] has suggested that transverse lines should be looked for in newborn infants in congenital lead poisoning.

Shadows in the ends of the bones similar to those of syphilitic osteochondritis, Type A, have been reported by Jackson and Park[12] in congenital scurvy, and in discussing the roentgenographic differential diagnosis of congenital scurvy in the first weeks of life they state that "unfortunately the white line is as marked in congenital syphilis as in scurvy." There may be many conditions other than those mentioned which influence the growing parts of the fetal skeleton and produce changes similar to those of syphilitic osteochondritis. This is beautifully illustrated by the non-syphilitic patient with erythroblastosis foetalis, Case VI, whose roentgenograms made in the fourth hour of life, show deep osteochondritic-like zones (Fig. 2*A*) which must have existed for many days and possibly several weeks before birth. In a series of routine roentgenograms of stillborn infants, Harris[10] found that transverse lines were frequently present and he attributed them to such non-syphilitic factors as ante-partum hemorrhage intoxication from abortifacient drugs, acute illnesses in the mother and "many such causes which might disturb the nutrition of the foetus." In view of the evidence which has developed in recent years the validity of diagnosing fetal syphilis from skeletal roentgenograms *alone* is open to serious question and the high incidence of fetal syphilis determined several years ago by this method *alone*, 25 to 45 per cent of the cases examined,[29] is probably excessive.

The nonspecificity of osteochondritis, Type A, has been emphasized by McLean[16–19] in the statement that the roentgenologist should be cautious in making the diagnosis of syphilis on this evidence alone and that the pathologist might be equally confused unless he were able to demonstrate spirochetes in the lesion. He appreciated that osteochondritis, Type B, was occasionally seen in conditions other than syphilis but he was not familiar with diseases other than syphilis which produced the disease frequently in the first months of life when scurvy is unlikely. It is evident from our material that there are a number of non-syphilitic diseases in the early months of life in which osteochondritis, Type B, of severe degree occurs. Osteochondritis, Types C and D, are listed by McLean as pathognomonic of syphilis. We have presented 3 instances (Cases XII, XIII and XIV) of these types of osteochondritis in non-syphilitic infants and it should be mentioned that these are not mild lesions. On the contrary, they are well developed and more severe (Figs. 3 and 4) than the similar lesions seen in many syphilitic infants.

Our experience with osteochondritis, Type F, agrees with that of McLean in that we have never seen foci of rarefaction in the angle of the cartilage-shaft junctions of several bones except in syphilitic infants. It is conceivable, however, that such lesions might develop early in multiple pyogenic osteomyelitis. We have also never

seen infractions across the ends of the several shafts (osteochondritis, Type G) except in syphilitic infants and we consider these lesions pathognomonic of syphilis in the early months of life at the present time. In older infants scurvy causes similar lesions.

The "saw-tooth" or "zig-zag" metaphysis has been considered characteristic of syphilis since Hochsinger's first roentgenographic demonstration of this lesion. Irregular projections from the epiphyseal margin of the primary calcified cartilage may be found at necropsy only in syphilitic bones. Park and Jackson[21] have studied this lesion histologically in minute detail and have recently shown that these irregularities are the result of extensions of the lattice around the cartilage canals. It should be kept in mind that in roentgenograms the margins of the shadows of the primary calcified cartilage are not always absolutely regular and also that mild rickets may produce serrations which are extremely difficult to differentiate from the syphilitic irregularities. This is particularly true in mild hypertrophic rickets in which there is little or no osteoporosis of the shaft. In our experience, slight irregularities of the ends of the shaft are usually not syphilitic and should be interpreted with considerable reservation.

OSTEOPERIOSTITIS

McLean[16–19] distinguished two types of syphilitic periostitis. The diffuse periosteal thickening, which occurs in an intact shaft independently of the lesions in the metaphyses, is generally thickest in the middle of the shaft and is not associated with any demonstrable lesion of the spongiosa. Ossifying periostitis or the hypertrophic osteoperiostitis of Péhu is similar but of increased magnitude.

The periostitis callosa of Schneider,[27] which resembles the callus of healing fractures, is found over breaks in the cortex of the shaft. It is usually thickest at the ends of the bones.

Syphilitic-like Osteoperiostitis in Non-syphilitic Infants.

Case xvi. *Diffuse osteoperiostitis in a non-syphilitic premature infant with healing rickets.* R.H. (516181) was first seen at three months of age because of malnutrition. His birth weight was reported as 1.7 kilograms. A cow's milk formula was given from birth and cod-liver oil and orange juice were started at two months of age. Clinical examination disclosed malnutrition, severe craniotabes, a rachitic rosary, enlargement of the epiphyses at the wrists and splenomegaly. Signs of lobar pneumonia were present in the right upper lobe.

Fig. 5. Syphilitic-like osteoperiostitis in a non-syphilitic premature infant three and a half months of age with healing rickets (Case xvi). Note the layers of calcium density surrounding the shafts of the femora and humeri.

The serum calcium and phosphorus were 8.7 mg. per 100 cc. and 4.4 mg. per 100 cc. respectively and there were 29.8 Bodansky units of serum phosphatase.

Kahn's test on the blood was negative.

Roentgenograms of the long bones showed severe hypoplastic rickets. Drisdol was given in progressively increasing doses to a maximum of 4,000 units daily. A second roentgen examination, nineteen days after the beginning of this vitamin D therapy, showed calcification of the cortical osteoid with multi-layered sheaths of

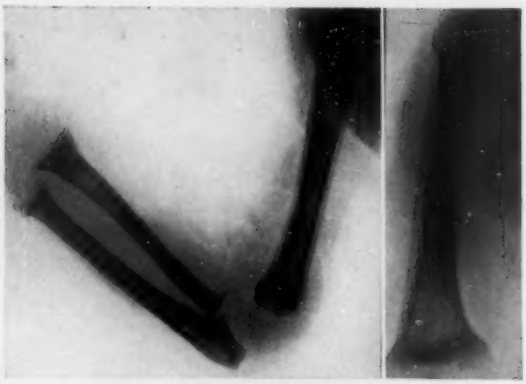

Fig. 6. Syphilitic-like osteoperiostitis and osteochondritis in a non-syphilitic full term infant three months of age with healing rickets (Case xvii).

calcium density surrounding the primary cortices (Fig. 5).

The negative Kahn test, the rachitic physical findings, the rachitic roentgenographic changes, the development of the osteoperiostitic-like changes following the administration of vitamin D all identify these lesions as rachitic rather than syphilitic.

Case xvii. *Diffuse osteoperiostitis associated with osteochondritic-like changes in a non-syphilitic full term infant with healing rickets.* L.P. (546983) was first brought to the clinic at three months of age because of cough and fever of five days' duration and vomiting for three days. The family history was negative for syphilis and both mother and father had had negative blood Wassermann reactions ten months previously.

Marked, bilateral occipital and parietal craniotabes, seropurulent nasal discharge, enlarged costochondral junctions and an enlarged abdomen were found in the physical examination.

A blood Kahn test was negative.

Roentgenograms of the forearms and thorax showed severe, hypoplastic rickets.

Vitamin D in the form of oleum percomorphi, 20 drops daily, was begun. Roentgenograms made eight days later showed healing rickets with delicate cloaking of the shafts by the partially mineralized cortical osteoid (Fig. 6). In addition there was a marked irregularity in the healing rachitic zones at the ends of the shafts which might be confused with syphilitic osteochondritis.

Case xviii. *Diffuse osteoperiostitis in a non-syphilitic premature infant.* R.S. (429951) was one of triplets born after a seven months' gestation. The blood of both parents had been tested twice with both Kahn and Wassermann techniques and gave negative reactions. A sibling, two years of age, was normal and had negative blood serology. One of the fraternal triplets also gave negative reactions to the Kahn and Wassermann tests; the second, having died at birth, was not examined serologically.

The patient was under observation in the Vanderbilt Clinic after the age of two and one-half months. He had repeated upper respiratory infections with chronic nasal discharge and noisy breathing which suggested syphilitic rhinitis. There was no blood in the nasal exudate and a skin eruption was not observed.

Physical examination at the sixth month showed marked pallor, stridor and excessive nasal discharge. There were physical signs of bronchopneumonia in the right lung which had been present for several months. Pneumonia was demonstrated in roentgenograms. The spleen was enlarged, with the lower pole 3 cm. below the costal margin. There was no clinical evidence of rickets.

The blood was examined three times with the Kahn and Wassermann tests and was negative.

Roentgenograms of the long bones at six months of age revealed heavy envelopes of

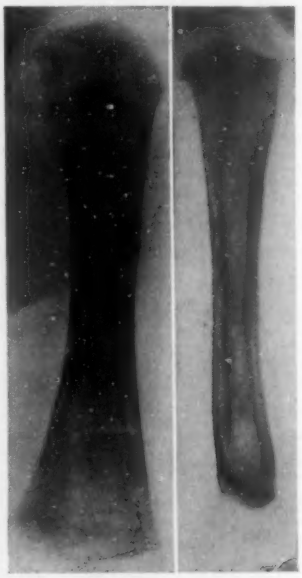

Fig. 7. Syphilitic-like osteoperiostitis in a non-syphilitic premature infant six months of age without evidence of active rickets (Case xviii).

calcium density surrounding the primary cortices (Fig. 7). There was at this time no roentgen evidence of active or healed rickets at the cartilage-shaft junctions. Whether or not early rickets, which had healed completely at the cartilage-shaft junctions leaving these residual changes around the shafts, was responsible for the osteoperiostitic-like lesions must remain an open question. It is possible that prematurity alone may give rise to such productive changes around the shafts.

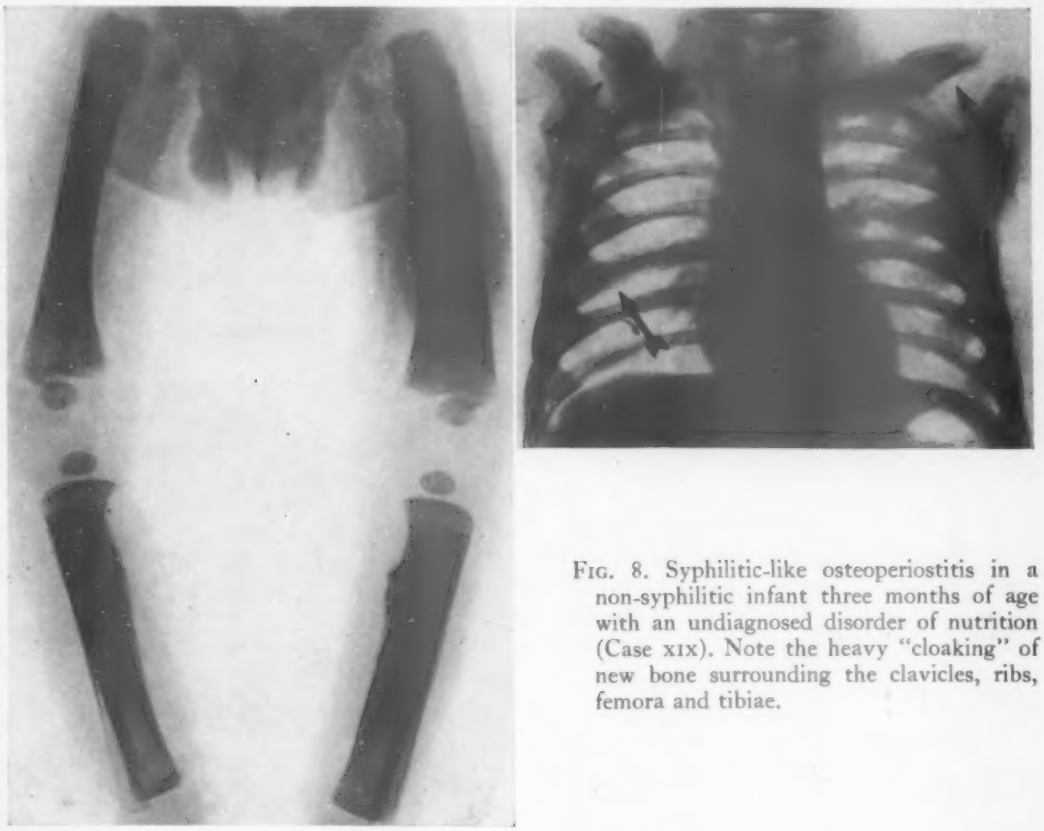

Fig. 8. Syphilitic-like osteoperiostitis in a non-syphilitic infant three months of age with an undiagnosed disorder of nutrition (Case xix). Note the heavy "cloaking" of new bone surrounding the clavicles, ribs, femora and tibiae.

Case xix. *Diffuse osteoperiostitis in a non-syphilitic infant with an undiagnosed disorder of nutrition.* M.P. (547799) was referred to the Hospital by Dr. Charles A. Lang in the twelfth week of life because of swelling of the right leg of four days' duration. He was born at term after a normal labor and weighed 3.2 kilograms. For the first ten days of life he nursed at the breast and then received a variety of formulae made from whole milk, Biolac milk or evaporated milk. Orange juice was begun in the fourth week, 10 drops daily, and was increased gradually until the seventh week after which he received one tablespoonful daily. The orange juice was warmed by the addition of hot or boiling water. The mother thought that a considerable part of this heated orange juice had been vomited. Oleum percomorphi was given in daily doses of 5 drops from the fourth to the ninth week and Drisdol, 3 drops daily, from the ninth to the twelfth week.

The infant thrived until the seventh week, after which there was a failure to gain and a low grade fever. At approximately the same time tenderness and limitation of motion of the left leg were noted. Four days before admission he was examined by Dr. Lang, who found a painful swelling of the left thigh and right shoulder. Dr. Lang gave orange juice immediately and noted considerable improvement in the tenderness of the extremities within forty-eight hours. Four days later when the infant entered the hospital the circumference of the left thigh was found to be 1.5 cm. greater than the right. There were no hemorrhages in the oral or conjunctival mucosae or in the skin.

The infant's blood was negative to the Kahn

test twice and his cerebrospinal fluid was negative in one examination. The mother's blood was also negative to the Kahn test. The blood serum contained normal concentrations of calcium and phosphorus. The blood count showed a moderate secondary anemia with normal platelet count of 580,000 per cu. mm., and normal bleeding and clotting time. The sedimentation rate of the erythrocytes varied from 33 to

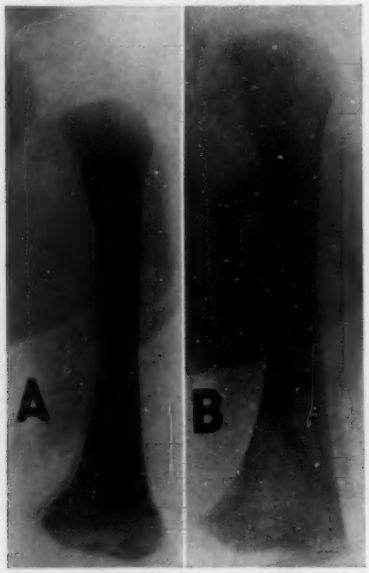

Fig. 9. Syphilitic-like osteoperiostitis in a non-syphilitic infant with traumatic periostitis of the newborn (Case xx). *A*, on the thirteenth day of life; *B*, at three months of age.

99 mm. in one hour. Chemical determination of the vitamin C content of the blood and urine yielded low concentrations in the blood with high concentrations in the urine. It was concluded that the large amounts of vitamin C excreted in the urine refuted the diagnosis of scurvy from a chemical standpoint. The Mantoux test was negative.

Roentgenograms of the skeleton revealed heavy thick cloaks of calcium density surrounding the diaphyses of the lower extremities, the clavicles and many of the ribs (Fig. 8). There were no changes at the cartilage-shaft junctions suggestive of scurvy or syphilitic osteochondritis. The upper extremities were negative with the exception of a single fine shadow parallel to the cortex of the right humerus. In the lower extremities the changes were more marked in the left femur than in the right. In both tibiae and in the left femur the external margins of these shadows were irregular, with small areas of diminished density beneath them. A small segment of one clavicle was excised and several layers of newly formed bone were found microscopically external to the old cortex.

The patient remained in the hospital for three weeks. For several days a low grade fever was present. In the second week roentgenograms of the thorax showed signs of bilateral pleural exudate. On thoracentesis a cloudy fluid was obtained containing 500 cells per cu. mm., 80 per cent of which were mononuclears. No bacteria were found in direct smears or in cultures. Tests for heterophile antibodies in the blood serum were negative, as were agglutination tests for the typhoid-dysentery group (Shiga, Flexner, Sonne, paratyphoid A and B) and for *B. melitensis* and *B. abortus*. The fever subsided after the second week of hospital residence, the tenderness and limitation of motion of the extremities disappeared and the patient was asymptomatic when he left the hospital at fifteen weeks of age. He has remained asymptomatic until the present time (eight months of age). The Kahn test was repeated at five and a half months and was again negative. Roentgenograms of the bones at the same time showed marked involution of the subperiosteal lesions.

The clinical and serological results in this case do not, we feel, warrant the diagnosis of syphilis. The negative Kahn tests in the twelfth week and the twenty-second week make syphilis highly improbable. Syphilitic bone lesions of this magnitude rarely involute rapidly at this age without antisyphilitic therapy, which was not administered to this patient. The microscopic findings in the clavicle are similar, if not identical, with the severe, active syphilitic subperiosteal lesion described by Schneider,[27] but it is extremely doubtful if an unequivocal micoscopic diagnosis of syphilitic periostitis can be made.[16–19].

The addition of heated and sometimes boiling water to the orange juice raised the question of scurvy, and the tender, inactive extremities which improved after orange juice was given in large amounts offered additional support for a vitamin C deficiency. However, the development of acute clinical scurvy after a depletion period of only six weeks has never been observed to our knowledge. The severity of the subperiosteal changes would indicate, were they of scorbutic origin, that extensive healing

had already occurred at the twelfth week of life. The presence of severe subperiosteal hemorrhage without changes at the cartilage-shaft junctions in active scurvy would be unique in our experience with scurvy and has not been described by others so far as we know. The findings do not in our opinion justify a diagnosis of either syphilis or scurvy and it seems reasonable at this time to ascribe the bone changes to an undetermined agent.

Case xx. *Diffuse osteoperiostitis in a non-syphilitic infant with traumatic periostitis of the newborn.* J.O. (364595) was delivered with considerable difficulty after a breech presentation. In the first day of life hypotonia of both legs and swelling of the lower thighs were evident and a cephalhematoma was present in the right parietal region. Kahn tests on the blood of mother and infant were negative. On the thirteenth day of life roentgenograms of the long bones showed fine lines of increased density parallel to the margins of the femora with fine, irregular fringes of bone density projecting from their lower margins (Fig. 9*A*). The other long bones were normal. The patient made gradual clinical improvement until at three months the muscle power and movements of the legs were normal. Roentgenograms at three months showed a persistence of the subperiosteal changes (Fig. 9*B*), but the fraying of the lower ends of the femora and projecting tags of bone density seen in the earlier films had disappeared. This patient never exhibited clinical manifestations suggestive of syphilis.

Case xxi. *Diffuse osteoperiostitis in a non-syphilitic infant with erythroblastic anemia (Cooley).* F.D. (466210) was the only child of healthy Italian parents, both of whom were born in the United States. The child was considered normal until the second month of life when pallor developed. At three and one-half months the mother felt a lump in his upper left abdomen. When first examined by us at four and one-half months the spleen was enlarged to the iliac crest and generalized pallor with jaundice of the skin and mucous membranes was noted. Blood examination showed changes typical of erythroblastic anemia with normoblasts varying in number from 11,600 per cu. mm. to 9,800 per cu. mm. Kahn tests on the blood of the infant, mother and father were negative.

Roentgenograms of the long bones showed the early skeletal changes of erythroblastic anemia. In addition, moderately heavy envelopes of calcium density surrounded the distal halves of the humeri (Fig. 10). The same changes were also present in the lower extremities.

This patient was under observation for three years, has consistently shown the typical findings of erythroblastic anemia in the blood, and has developed severe erythroblastic changes in the skeleton, although the subperiosteal

Fig. 10. Syphilitic-like osteoperiostitis in a non-syphilitic infant four and a half months of age with erythroblastic anemia (Cooley) (Case xxi).

changes disappeared after the first year. He has never shown any clinical manifestations suggestive of syphilis. Sections of the spleen, removed when the patient was seventeen months of age, showed no syphilitic changes.

Case xxii. *Osteoperiostitis callosa in a non-syphilitic infant with multiple osteomyelitis due to gonococcus.* F.G. (370870) was first seen at three weeks of age when he had an abscess of the left ankle region which healed after incision and drainage. He returned at five weeks of age with swelling of the right elbow, right ankle and stiffness of the left hip. Aspiration of each of these joints yielded pus containing a gram-negative coccus which resembled the gonococcus. Blood cultures were negative.

A series of roentgenograms of the right arm showed distention of the elbow joint with marked destructive and productive changes in the distal end of the humerus and proximal ends of ulna and radius which simulated

syphilitic multiple osteomyelitis and osteoperiostitis callosa very closely. These changes at eight weeks of age are shown in Figure 11. Osteochondritic-like changes were present at the distal ends of the radius and ulna. Similar destructive and productive changes were present in the roof of the acetabulum of the left ilium and head of the left femur.

The patient recovered after five months of local and constitutional treatment. A pathological dislocation of the left hip was still present when the patient was last seen at six months of age.

FIG. 11. Syphilitic-like osteoperiostitis (osteoperiostitis callosa) in a non-syphilitic infant eight weeks of age with multiple osteomyelitis due to gonococcus (Case XXII). Note the thick layers of new cortical bone at the ends of the shafts and the osteochondritic-like changes at the distal ends of the ulna and radius.

There was no known syphilis in this family. The Kahn reaction of the patient's blood was negative in the third week, the sixth week and at the sixth month of life. The patient presented no clinical manifestations of syphilis during the period of observation (third to the sixth month).

COMMENT

In healing rickets mineralization of the subperiosteal osteoid consistently produces cloaking of the shafts which cannot be differentiated roentgenographically from diffuse syphilitic periostitis in both full term and premature infants (Cases XVI and XVII, Figs. 5 and 6). It should be emphasized that these subperiosteal rachitic changes may persist for weeks and months after the rickets at the cartilage-shaft junctions has healed completely and that residual rachitic cloaking of the shafts may be present when the ends of the bones are normal in appearance.

Wimberger[34] mentions the similarity of the symmetrical periosteal changes in syphilis and rickets, and he used the age of the patient as a differential diagnostic feature in the belief that rickets is rarely found in the first three months of life. This age differential is not valid at the present time because rickets is frequently found in very young infants, particularly prematures.[5,6]

The most marked case of periosteal cloaking observed by McLean was in a negro infant with rapidly healing rickets. He also mentions that one should keep in mind that rapidly growing normal infants may show fine periosteal shadows on the mesial aspects of the tibiae which an overenthusiastic observer might mistake for syphilitic periostitis. In histological examinations McLean found nothing specific about the new bone formation in syphilitic periostitis and doubted whether a microscopic section of a syphilitic periosteal lesion could be differentiated from the thickened cortex overlying tuberculous osteomyelitis or overlying the sequestrum of any pyogenic osteomyelitis. He considered osteoperiostitis callosa to be diagnostic of syphilis but this lesion has since been reported in pyogenic osteomyelitis by Epstein and Klein,[8] and a typical example of osteoperiostitis callosa is seen in Case XXII (Fig. 11) associated with multiple gonococcal osteomyelitis.

The fact that syphilitic osteoperiostitis is

usually accompanied by osteochondritis or osteomyelitis before the fifth month of life[24] is of major diagnostic importance. In syphilis, subperiosteal changes exist alone only after these other lesions have healed. McLean found this to be true in 95 per cent of his cases. Periosteal cloaking in the early weeks of life is therefore rarely indicative of syphilis if it is the sole lesion present in the skeleton.

Syphilis and rickets are not the only causes of subperiosteal bone production in young infants, since it has been observed in this series of cases in erythroblastic anemia, in traumatic ossifying periostitis of the newborn, in prematurity and in undiagnosed conditions. Subperiosteal changes have been demonstrated roentgenographically early in erythroblastic anemia,[2] and Whipple and Bradford[33] have found splitting of the costal cortices in anatomic specimens from a fatal case of erythroblastic anemia.

Trauma to the skeleton of the fetus during breech delivery may also produce thick periosteal cloaking and present a roentgenographic picture which is easily confused with syphilitic periostitis. The thickening of the cortex in such cases persists for several months after birth. In Case xx such changes are limited to the femora. Snedecor, Knapp and Wilson[30] found that the tibiae may also be similarly involved and occasionally the humeri following attempts to deliver a head with the arms extended.

The rapid growth of the skeleton in nonsyphilitic premature infants may be a frequent cause of thickening and lamellation of the cortices. In Case xviii subperiosteal cloaking is present with no evidence of either active or healed rickets at the metaphyses.

There may be many other unrecognized conditions and factors which cause excessive subperiosteal bone production and result in "cloaking" of the shafts. This is suggested in Case xix where marked subperiosteal lesions surround the shafts of the long bones of the lower extremities, the clavicles and several ribs, although no etiological agent could be identified after elaborate clinical, laboratory and biopsy investigation of the patient. Meier[20] has seen hyperplastic periostitis in an infant three months of age with congenital heart disease. At six months of age when the cardiac condition had improved the periostitis had disappeared.

OSTEOMYELITIS

Roentgenographically the osteomyelitic lesion is essentially an area of destruction of cancellous bone, with or without changes in the overlying cortex, and in this respect resembles both pyogenic and tuberculous osteomyelitis. In both syphilitic and nonsyphilitic osteomyelitis the lesions are usually situated at or near the ends of the shafts. In a single bone, syphilitic osteomyelitis cannot be differentiated from other types of osteomyelitis by roentgenographic methods alone.

The most diagnostic features of syphilitic osteomyelitis are said to be the multiplicity of the lesions and their approximately symmetrical distribution in the skeleton.[16–19] It should be kept in mind, however, that in infancy both pyogenic osteomyelitis and tuberculosis of the diaphyses may involve more than one bone and that osteomyelitis in several bones is not necessarily indicative of syphilis. An example of multiple pyogenic involvement of the skeleton has been given in Case xxii. In the report of Epstein and Klein[8] there are several similar examples of multiple pyogenic osteomyelitis simulating syphilitic osteomyelitis with osteoperiostitis callosa.

Multiple benign tuberculosis of the shafts was first described by Jüngling.[13] Schwentker[28] saw similar lesions in an infant who had both syphilis and tuberculosis and he commented on the difficulty of determining whether syphilis or tuberculosis was responsible for the skeletal changes in his case. The similarity of this type of bone tuberculosis and syphilitic osteitis has also been pointed out by Lovett and Wolbach[15] and by Bromer and Downs.[1] In

the opinion of Pomeranz[25] syphilis and tuberculosis of the metacarpals, metatarsals and phalanges cannot be differentiated roentgenographically.

SUMMARY

Roentgenograms of the skeletons of 550 non-syphilitic infants were studied. The significant clinical and laboratory data with roentgenograms from 22 selected cases are presented.

These roentgenograms show changes indistinguishable from syphilitic osteochondritis, syphilitic osteoperiostitis and syphilitic osteomyelitis.

The earliest and most frequent forms of syphilitic osteochondritis were simulated in 14 patients with bacteriemia (due to staphylococcus, pneumococcus and tubercle bacillus), erythroblastosis foetalis, septic hemolytic anemia, familial hemolytic anemia, multiple birth injuries, congenital atresia of the biliary apparatus, severe malnutrition, unexplained hemiparesis, protozoan encephalitis and maternal bismuth therapy. In this non-syphilitic group no cases resembling the following rarer types of syphilitic osteochondritis were found; (1) "saw-tooth" metaphyses, (2) foci of rarefaction in the angles of the cartilage-shaft junctions, (3) multiple infractions through the ends of the shafts.

Both diffuse syphilitic osteoperiostitis and syphilitic osteoperiostitis callosa were simulated in healing rickets, prematurity, traumatic periostitis of the newborn, gonococcal bacteriemia and undiagnosed disorders of nutrition.

Syphilitic osteomyelitis was simulated in multiple pyogenic osteomyelitis. Wimberger's sign, symmetrical osteomyelitis of the proximal medial aspects of the tibiae, was not encountered in this non-syphilitic group.

CONCLUSIONS

The roentgenographic skeletal lesions of early infantile syphilis are simulated in a wide variety of conditions in young infants.

The roentgenographic findings in the skeleton *per se* are not conclusively diagnostic of early infantile syphilis and they should not be used *alone* as presumptive evidence for the institution of antisyphilitic therapy.

Osteochondritis, osteoperiostitis and osteomyelitis present in combination are more indicative of syphilis than the presence of any of these lesions alone.

In evaluating roentgenographic bone changes in young infants we would do well to remember the advice of Wimberger and of McLean.

Wimberger: "If in a case there are no other conclusive factors which make possible the diagnosis of syphilis, the roentgen findings as a rule will not make the diagnosis."

McLean: "Roentgenographic examination is not intended to offer the clinician a substitute for scrupulous clinical examination nor is it suggested that roentgenology will ever assume the place now held by serology in the diagnosis of the disease. It is only by the correlation of clinical, serologic and roentgenologic observations that the knowledge of congenital syphilis will be furthered."

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ANGIOSARCOMA OF BONE*

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ANGIOSARCOMA occurring in bone is a rare disease. Only one case was found in 12,000 autopsies performed at Cleveland City Hospital. Geschickter and Copeland[4] fail to include this entity in their extensive material on tumors of bone. During the last half-century sporadic reports have appeared in the literature of this neoplasm or of closely allied diseases under the captions of angiosarcoma, endothelioma, angioendothelioma, malignant angioma, periosteal endothelioma, perithelioma, telangiectatic sarcoma of bone and malignant bone aneurysm. The last two terms are today considered subtypes of osteogenic sarcoma. That there are differences of opinion as to the origin and nature of this unusual type of new growth cannot be denied from a review of the literature. Grossly, it is characterized by multiple new growths destroying bone, red in color, and varying in size from a few millimeters to several centimeters in diameter. Histologically, the tumor is composed of large endothelial cells closely associated with blood vascular channels or spaces filled with blood. The bone is destroyed wherever it is in relation to tumor; new bone production is not evident. Our case showed considerable fibrillar arrangement of the stroma, interlacing large spindle and polyhedral mononuclear cells of endothelial character.

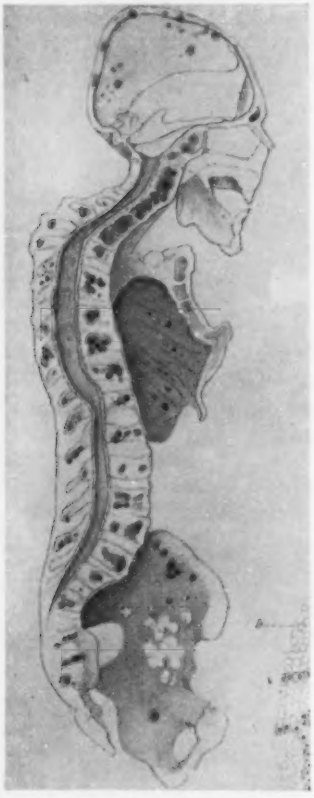

FIG. 1. Photograph of specimen from Marckwald's[7] unusual case of multiple intravascular endothelioma in all the bones of the skeleton.

Marckwald[7] (1895) reported a case of multiple intravascular endothelioma in all the bones of the skeleton which he termed parenthetically either myeloma or angiosarcoma. He stated that in the literature prior to that time relatively few cases of primary new growths of bones with symmetrical involvement of a large number of skeletal bones had been reported. The patient was a fifty-six year old mason who had intermittent fever, pain, anemia, marked loss of weight and diminution in stature. At autopsy, symmetrical involvement of almost all the bones of the body was found. Multiple, small, reddish-brown tumors were situated in the bone marrow causing destruction of bone (Fig. 1). From a clinical standpoint the disease simulated very closely multiple myeloma. Ewing[2] states that Marckwald's diagnosis of intravascular endothelioma seems fully justified and

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that this remarkable tumor may be designated as an endothelioma of vascular origin. The gross skeletal findings simulate in many respects the findings in the present case report.

Howard and Crile[6] (1905) reported 4 cases which they termed endothelioma or perithelioma of bone and reviewed the literature on 19 other cases. Multiple destructive lesions of bone were the characteristic finding in their patients. They believe that endothelioma arises from the endothelium of either blood or lymph vessels.

Symmers and Vance[12] (1916) reported a case of multiple primary intravascular hemangio-endothelioma of the osseous system associated with symptoms of multiple myelomata. The subtitle of their article was "A lesion hitherto undescribed." There was no reference to Marckwald's published case; it is the writer's opinion that the latter's case was like that described by Symmers and Vance. The left ischium, manubrium sterni, upper end of the right humerus, upper segment of the occipital bone and first right rib were involved by destructive new growths. The histologic features were similar to those found in Marckwald's and our case.

Mauguière[8] (1920) published a report of angiosarcoma of the clavicle in a man aged sixty. Clinically, a large tumefaction was present over the left shoulder. Roentgenograms showed a destructive process in the clavicle which was interpreted as an osteosarcoma. After surgical excision, the pathologic report was angiosarcoma (endothelioma) of bone.

Wells[13] (1921), in reporting a case of multiple vascular tumors of bone in a male, aged forty-five, found that the soft tumor tissue exhibited the typical features of myeloma of the myeloblastic type. He concluded that, "a growth that begins as a myeloma may take on the characteristics of a neoplasm of vascular origin, with no remnants of the original tumor to be found in the entire bone tumor."

Stone[11] (1929) was one of the first to publish a report of angiosarcoma of bone with roentgenographic findings in the skull. The patient was a white male, aged twenty-five, with multiple, small, punched-out destructive lesions in the cranial vault. Small, roughly circular areas of rarefaction, not exceeding 2 cm. in diameter, were also present in the heads of both femora, in the pelvic bones, in the first dorsal vertebra, in the right ulna and in some ribs. Roentgenographically, the lungs were riddled with small nodules a few millimeters in diameter. A biopsy of a small nodule from a rib was diagnosed angiosarcoma (Dr. C. L. Connor). The roentgen appearance of the cranial lesions were not unlike those of multiple myeloma.

One of the more recent reports is that of Freilich and Coe[3] published in 1936. Roentgen studies showed a destructive lesion involving the superior border of the right scapula with swelling of the soft tissue. Microscopically, the tumor proved to be angiosarcoma (Dr. Jaffe).

Hodges, Phemister and Brunschwig[5] write about telangiectatic sarcoma, angiosarcoma and malignant bone aneurysm as one type of tumor. Ewing[2] classifies telangiectatic sarcoma or malignant bone aneurysm as a form of osteogenic sarcoma. The latter concept has also been accepted by Geschickter and Copeland.[4] Angiosarcoma of bone is distinct from osteogenic sarcoma.

In the classification of tumors of bone by the Registry of Bone Sarcoma, item Number VI is Angioma (*benign; malignant*). In reporting on the nomenclature used by the Registry, Codman[1] stated in 1925:

> Under the heading of angioma you will notice the sub-heading of benign and malignant. . . . The malignant forms of angioma in bone are evidently rare. We have left this subdivision more as a compliment to those who use the term angiosarcoma than because we need it to include any group of our tumors. I have invited my colleagues and many other pathologists, privately and publicly, to register a case of angiosarcoma; no one has yet done it. The fact is that this term was used in the past for the vascular or telangiectatic forms of

Fig. 2. *A*, anteroposterior roentgenogram of right femur showing numerous irregular areas of destruction in middle and lower thirds of cortex and medulla. *B*, lateral projection showing punched-out and cystic characteristics of bone destruction in right femur.

osteogenic sarcoma. I mention it largely because I hope no roentgenologist will use it.

When the case reported in this article was submitted by Dr. L. A. Pomeroy, Director of the Tumor Clinic of Cleveland City Hospital, to the Registry of Bone Sarcoma in 1933, Codman[1] rendered the following opinion:

It seems to me that at last we have really got a tumor which can be placed in the pigeonhole of Angioma . . .

*Malignant (Angiosarcoma)**

This opinion was concurred in by Ewing. The final classification of the tumor (Reg. No. 1530) by the committee was *Hemangioendothelioma.*

REPORT OF CASE

C. B., female, white, married, aged forty-eight, entered the medical service of Dr. C. P. Huston, Cleveland City Hospital, on March 11, 1933, complaining of a painful swelling in her right thigh. The family history was irrelevant. In 1923 she had an attack of rheumatic fever with dyspnea and recurrence of shortness of breath in 1926. She had never been pregnant. Menopause occurred at the age of forty-five. When the patient was eight years old she experienced an attack of rheumatism which lasted throughout the winter. She was hospitalized from January 8 to February 13, 1930, with the diagnosis of rheumatic heart disease, auricular fibrillation, mitral stenosis and myocardial insufficiency. In addition to the abnormality of the heart, a defective nasal septum was noted. Blood Wassermann examinations were as follows: Jan. 10, 1930, four plus; Jan. 13 and 14, negative; Jan. 17, two plus; Jan. 20, negative. On January 14 the spinal fluid Wassermann reaction was negative. After discharge from the hospital in 1930, the patient was observed on numerous occasions in the Out-Patient Department where she was treated for rheumatic heart disease.

* Italics supplied by the writer.

One month before admission, the patient developed a stiff right knee joint and painful localized swelling appeared several centimeters proximal to the knee on the inner surface of her right thigh. Because of inability to stand on her right leg, the patient remained in bed during the month prior to admission. For five weeks before coming to the hospital, she had complained of a productive cough. There was no history of injury.

Examination of the right thigh showed a mass on the lower medial aspect about 4×4×5 cm., of fairly firm consistence but without definite fluctuation. There was neither redness of the skin nor local heat.

Except for a trace of albumin on March 11, 1933, the examination of the urine was negative. March 12, 1933: Red blood cells, 3,500,000; white blood cells, 10,000; hemoglobin (Sahli), 90 per cent. Polymorphonuclear leukocytes 73 per cent, mononuclears 27 per cent. March 13, 1933: Blood Wassermann reaction was four plus.

Roentgen Studies. March 21, 1933: Anteroposterior and lateral roentgenograms of the right femur showed numerous sharply circumscribed areas of bone destruction varying in size from a few millimeters to several centimeters in diameter (Fig. 2*A*). In the lateral view these areas were somewhat cystic in appearance (Fig. 2*B*). Anteroposterior projection of the pelvis, upper femora and left leg revealed similar destructive areas in the ischial and pubic bones, the upper third of the right femur and medial cortex of the middle third of the left fibula. Lateral view of the skull showed circular, punched-out areas of bone destruction from 0.5 to 1.5 cm. in diameter (Fig. 3). Examination of the chest showed the cardiac silhouette to have a mitral configuration. The transverse diameter was moderately increased in size indicating the presence of cardiac enlargement. The right seventh rib presented two areas of bone destruction in the posterior axillary line and near the angle of the rib (Fig. 4).

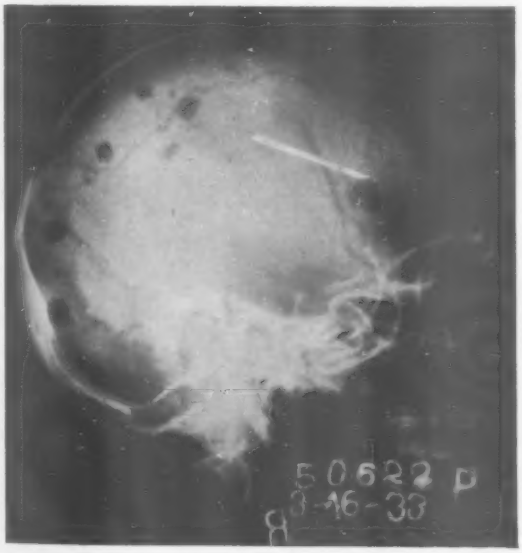

Fig. 3. Lateral view of skull showing numerous punched-out areas of bone destruction 0.5 to 1.5 cm. in diameter. Horizontal white line is artefact due to hairpin.

Fig. 4. Roentgenogram of chest showing mitral configuration of heart shadow and increase in transverse diameter resulting from chronic rheumatic heart disease. Note destruction in right seventh rib.

The working diagnosis was rheumatic heart disease, multiple bone tumors and tertiary syphilis.

A biopsy was made on March 28, 1933, from the swelling on the medial surface of the right thigh. Grossly, the soft tissue showed only clotted blood. A piece of the involved bone was removed.

Treatment was symptomatic. The patient gradually became worse and died on April 1, 1933.

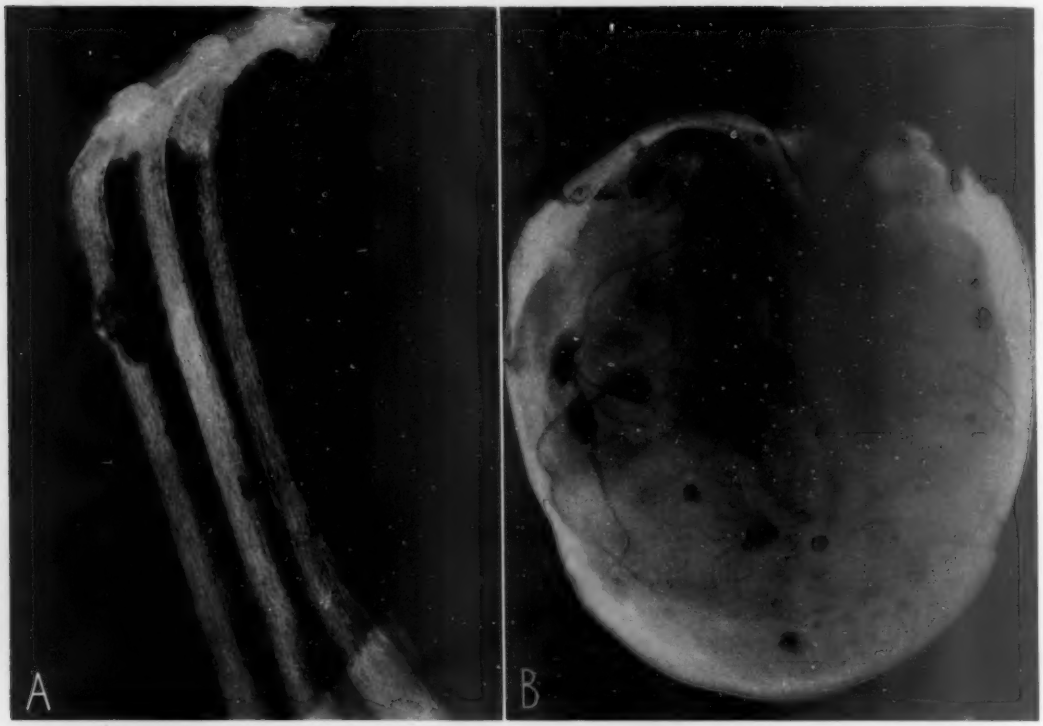

Fig. 5. *A*, roentgenogram of specimen of right fifth, sixth and seventh ribs showing large destructive process by tumor of seventh rib near angle. *B*, roentgenogram of specimen of vertex of skull showing sharply defined destructive areas of varying sizes.

The final clinical diagnoses were rheumatic heart disease with mitral stenosis, multiple bone tumors, tertiary syphilis and cachexia.

Post-mortem examination was performed on the day of the patient's death by Dr. T. T. Frost to whom I am indebted for the autopsy observations. On the lateral portion of the lower third of the right femur there was a large, spongy, dark red mass of tissue projecting from the medullary canal measuring 4×3 cm. and projecting 9 mm. above the surface of the bone. On section, this tissue was contiguous with the mass in the medullary canal and showed a dark red, smooth surface, slightly streaked with yellow and gray. The lower end of the bone was necrotic and infiltrated with the same spongy red material which filled the medullary canal completely. Several of the ribs contained masses which projected above the periosteum, similar in consistence to that in the femur and varied in size from 1 mm. to 2 cm. in diameter. On section, the larger ones showed marked destruction of medulla and cortex. Just lateral to the articulation of the spine was a large mass 2×1.5 cm. infiltrating and destroying the posterior portion of the seventh rib (Fig. 5*A*). The lungs were crepitant throughout and contained numerous nodules of firm consistence; the cut surface was grayish red, dry and somewhat spongy. These nodules were not encapsulated and projected to a considerable degree above the cut surface of the lung. The external surface of the calvarium contained seven or eight subperiosteal areas of bone destruction varying from 7 mm. to 2 cm. in diameter, the largest one being situated just to the left of the lambdoid suture (Fig. 5*B*). In these areas the bone was replaced by a soft, spongy material which varied from gray to dark red and was irregularly mottled. The largest nodule extended 3 mm. above the cut surface of the calvarium. On the inner surface, several additional areas of similar nature were present and involved only the inner table. Several of those seen on the exterior were confined to the outer table. The dura was slightly adherent and thinned over the areas of bone destruction. In the left parietal and right occipital regions of the brain, two areas were compressed by infiltration of red jelly-like material.

The microscopic examination of the tumor

showed tissue composed of various sized, irregularly arranged vascular spaces lined by bizarre endothelial cells, some of which were several layers deep and supported on a delicate fibrillar network which contained large numbers of cells similar to those lining the vascular spaces. These cells were large, polyhedral, and contained a generous amount of cytoplasm staining faintly acidophilic and large irregular vesicular nuclei with prominent nucleoli. Mitotic figures were present. Large numbers of free erythrocytes were present throughout in addition to those in the vascular spaces. Necrosis was present to a considerable degree. Where tumor involved bone, osseous destruction was evident (Figs. 6*A*, *B* and *C*). *Pathologic Diagnoses:* Hemangiosarcoma involving femur, skull and ribs with metastases to lung and brain. Chronic rheumatic endocarditis involving mitral and tricuspid leaflets. Mitral stenosis and insufficiency. Vegetative endocarditis of mitral leaflets. Thrombosis of left auricle. Generalized arteriosclerosis. Old infarcts in kidney and spleen. Arterial nephrosclerosis. Chronic cholecystitis and cholelithiasis.

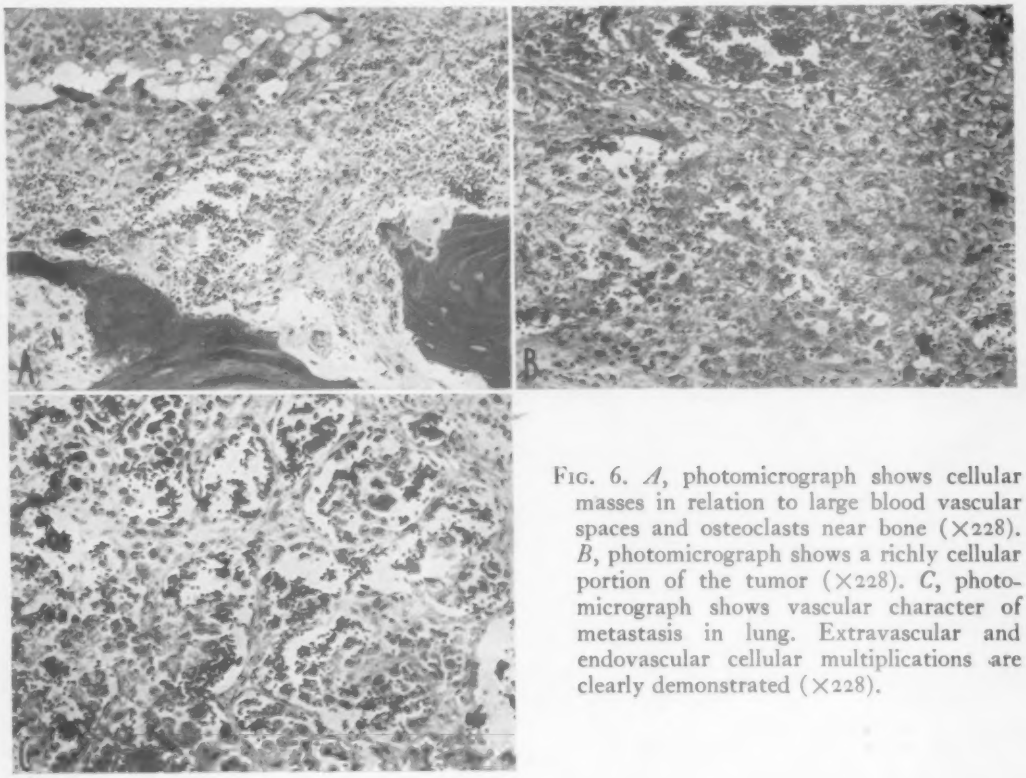

Fig. 6. *A*, photomicrograph shows cellular masses in relation to large blood vascular spaces and osteoclasts near bone (×228). *B*, photomicrograph shows a richly cellular portion of the tumor (×228). *C*, photomicrograph shows vascular character of metastasis in lung. Extravascular and endovascular cellular multiplications are clearly demonstrated (×228).

COMMENT

This case represents an extremely rare type of primary neoplasm of bone occurring in multiple foci. It is reasonable to consider this disease as a systemic one. Stewart[10] opened the question as to whether or not rheumatic heart disease with chronic circulatory stasis might have been of etiological significance. He suggested the possibility of the formation of peripheral thrombi undergoing organization. Angiosarcoma is without known etiology similar to many other varieties of neoplasms occurring in the body. The roentgen findings in the presented case are clearly demonstrated even though they cannot be differentiated from those of multiple myeloma.

The final diagnosis of angiosarcoma of bone depends upon microscopic observation of a malignant endothelial tumor with distinct vasoformation.

Whether or not radiation therapy would be of value in angiosarcoma of bone is not known. Careful search of the literature

fails to reveal any information on radiation response to this form of tumor. Schreiner and Wehr[9] reported good regression following irradiation of a soft tissue angiosarcoma of the hand. Further experience with varying techniques is needed before the value of radiation therapy is known.

Several conditions which might be confused with angiosarcoma involving bone should be considered in the differential diagnosis: *Multiple myeloma* closely simulates this disease. Roentgenologically, the lesions are much more numerous in multiple myeloma. The ultimate differentiation depends on histopathologic characteristics. *Metastatic new growths* show a greater irregularity and a moth-eaten appearance of the bone destructive lesions. The well-defined punched-out features of angiosarcoma are lacking in metastatic carcinomas. *Osteogenic sarcoma* involves only one bone except in rare instances. New bone production is a common feature except in the pure osteolytic variety. Young individuals are more often affected. Angiosarcoma is osteolytic and involves multiple areas in the skeletal system. *Xanthomatosis of bone* has the characteristic "geographic" appearance of destruction of the cranial vault not present in neoplastic diseases. The young are usually affected and exophthalmos and polyuria are accompanying signs. The destructive cranial lesions of angiosarcoma are of smaller size.

SUMMARY

Angiosarcoma occurring in multiple bones of the skeletal system is a distinct entity of great rarity, the diagnosis of which may be inferred roentgenologically and established by microscopic examination. The pertinent literature on the subject indicates that only a few cases can be classified under this caption, and that many terms have been applied to the disease. Case No. 1530 of the Registry of Bone Sarcoma is the first one submitted to be classified as "angioma, malignant." Roentgen features are emphasized because of their unusual character and their close simulation to multiple myeloma. Response to radiation therapy is as yet unknown. Diagnostic points are given to differentiate angiosarcoma from similar destructive bone diseases.

Grateful acknowledgment is made to Dr. Howard T. Karsner for his valuable criticism and excellent photomicrographs, and to other members of the Department of Pathology, Cleveland City Hospital, for their kind cooperation.

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Vol. 42, No. 5

THE ANTERIOR AND POSTERIOR "NOTCH" SHADOWS SEEN IN LATERAL ROENTGENOGRAMS OF THE VERTEBRAE OF INFANTS

AN ANATOMIC EXPLANATION*

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IN LATERAL roentgenograms of the vertebral bodies of infants there appear horizontal, conical shadows of lessened density extending inwards from the anterior and the posterior walls of the bodies. The anterior conical shadows are more clear cut than the posterior ones. Both are well defined. Confusion exists as regards the interpretation and explanation of these shadows. It was considered desirable to investigate these shadows and to explain their presence upon an anatomic basis. This paper presents the data obtained by such an investigation and the anatomic explanation of these roentgen shadows.

In our paper before this Society in 1931, we demonstrated that the human vertebral body, in both young and old, contained a huge ramifying and intercommunicating system of venous sinusoids.[1]

In 1937 before the Fifth International Congress of Radiology we discussed the interpretation of various vertebral body shadows.

In this paper we wish to present anatomic data for the interpretation of anterior and posterior "notch" shadows as seen in the lateral roentgenograms of the vertebral bodies of newborns and infants.

I. POSTERIOR "NOTCHING"

Posterior "notching" of the thoracic vertebral bodies is not frequently seen in lateral roentgenograms of the thoracic spine due to the superimposed shadows of the lateral masses. In lateral roentgenograms of the lumbar bodies it is seen commonly.

FIG. 1. Photograph of posterior surface of the bodies of three adult vertebrae. The laminae and processes have been removed by sawing through the pedicles. The posterior foramina are seen in this dry preparation.

The examination of any vertebral body at any age will show the presence in the posterior wall of a definite "notch." During

[1] Wagoner, G., and Pendergrass, E. P. Intrinsic circulation of the vertebral body, with roentgenologic considerations. AM. J. ROENTGENOL. & RAD. THERAPY, 1932, *27*, 818–826.

* From the Laboratory of Orthopedic Research, Harrison Department of Surgical Research, and the Department of Radiology, School of Medicine, University of Pennsylvania, Philadelphia, Pa. Read at the Thirty-Ninth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 20–23, 1938.

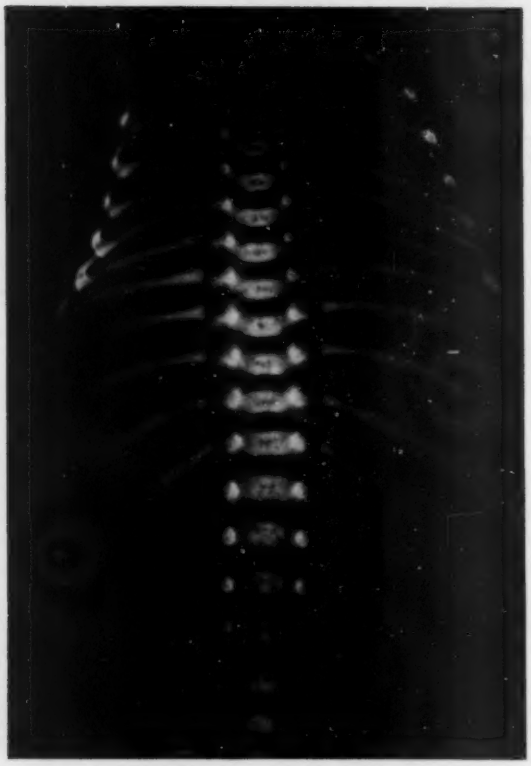

Fig. 2. Anteroposterior roentgenogram of thoracic spine of a newborn. The posterior notches and foramina of the bodies are clearly shown.

fetal life and early infancy, the posterior "notch" is relatively larger than during adult life. However, it is present during all age periods.

The posterior body "notch" is real and actual. Gross examination of dried vertebrae from which the laminae have been cut show a large indentation of the posterior wall of the body in its central area. In this indentation are two large and two or more smaller openings. These openings extend through the bone cortex and into the substance of the body. Through the two larger openings emerge the two large posterior veins. Through the two or more smaller openings enter the nutrient arteries.

Histological examination of the vertebral bodies of fetuses and newborn infants show the posterior "notch" to extend anteriorly to the center of the body. From sections cut in the sagittal, coronal, and horizontal planes, the shape of this "notch" can be reconstructed. It is seen that the "notch" has the configuration of a cone whose apex is blunted. The sides of the cone are bounded by heavy bone trabeculae. A V-shaped septum of trabecular bone penetrates its base and forms two large channels from which the vessels enter and leave the body.

Thus it may be stated that the posterior "notch" shadow seen in lateral roentgenograms of human vertebrae is produced by an actual indentation of the posterior cortical wall. This indentation marks the site of the entrance of veins and the emergence of arteries.

2. Anterior "Notching"

"Notching" of the anterior walls of the vertebral bodies of the young is a common phenomenon whose cause has been the subject of much speculation. The views of Scheuremann, Hanson, Köhler, and others, are so well known as to need little discussion.

In order to determine the cause of anterior "notching," the spinal column of a number of fetuses and newborn infants were examined. Lateral roentgenograms of

Fig. 3. Lateral roentgenogram of the first lumbar vertebra of an adult showing the posterior notch.

these columns were made and the shadows of anterior "notching" were found to be present in all of the vertebral bodies.

Examination of the spinal columns proceeded by three methods:

1. Injection with a roentgen opaque mass of (*a*) the arterial blood supply of the vertebrae and (*b*) of the venous drainage of the vertebrae.*

Fig. 4. Lateral roentgenogram lower thoracic and lumbar spine of a newborn. The characteristic anterior "notching" of the bodies is present.

2. Gross examination and gross dissection of the individual vertebrae.

3. Microscopic examination of many thousand serial sections of the vertebral bodies made in (*a*) the sagittal, (*b*) the coronal, and (*c*) the horizontal planes.

From the method of arterial and venous injections, our findings as reported in 1931 and 1932 were corroborated and extended.

Gross examination of the external surfaces of the vertebral bodies failed to show any indentations of the anterior or lateral walls. And this, despite the fact that lateral roentgenograms of these same bodies showed sharply defined "notch" shadows extending inwards from the middle portion of the anterior walls. The vertebral bodies were then cut in various vertical planes. Gross examination of the cut surfaces failed to show any indentation or "notching."

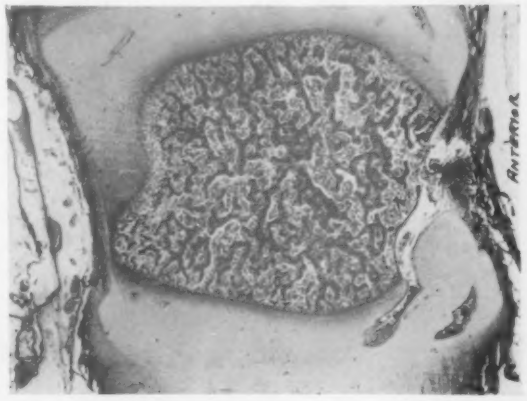

Fig. 5. (S-1. 17×. Hansen-Bock stain.) Parasagittal section of lumbar vertebra of a newborn. Anteriorly can be seen the orifice of one of the anterolateral veins. Extending downwards well into the cartilaginous end plate is a vertical arm of the venous sinusoid.

From these data, but one conclusion was possible. Actual "notching" or indentation of the anterior walls of the vertebral bodies was not present. Consequently, the roentgenologic appearance of "notching" of the anterior vertebral walls was apparent, but not real.

To explain the origin of the shadows of "notching," it was necessary to seek within the substance of vertebral bodies which showed, by lateral roentgenogram, the existence of "notch" shadows.

Such a search was made by the microscopic examination of numerous serial sections of the vertebral bodies as outlined above.

In the sagittal sections it was found that the superior and inferior zones or end plates of the vertebral bodies were formed of densely calcified cartilage. The central

* This phase of the work was done in the Department of Anatomy, Graduate School of Medicine, University of Pennsylvania.

FIG. 6. (S-2. 17×. Hansen-Bock stain). Parasagittal section near the midline. The demarcation of anterior and posterior "notches" by limiting trabeculae is easily seen. The presence of sinusoidal material within these areas is well shown. The bony system of the posterior notch is prominent in this section.

FIG. 7. (S-3, 17×. Hansen-Bock stain). Sagittal section. Here are clearly shown both the anterior and posterior "notches," the absence of an anterior cortical wall and the presence of the central sinusoid.

zone of the body was comprised of well differentiated osseous tissue. Ossification of this central zone had proceeded peripherally from a central point. As the trabeculae approached the cartilage of the upper and lower zones, they were less well defined and finally fused with the cartilage. The intertrabecular spaces contained normal marrow elements, in addition to definite sinusoidal spaces.

Approximately the same facts were noted when the coronal and horizontal sections were examined.

The anterior wall, in sagittal and horizontal sections, had an entirely different structure from the posterior wall. The ventral or external surface of it was limited by a wide band of dense fibrous tissue in addi-

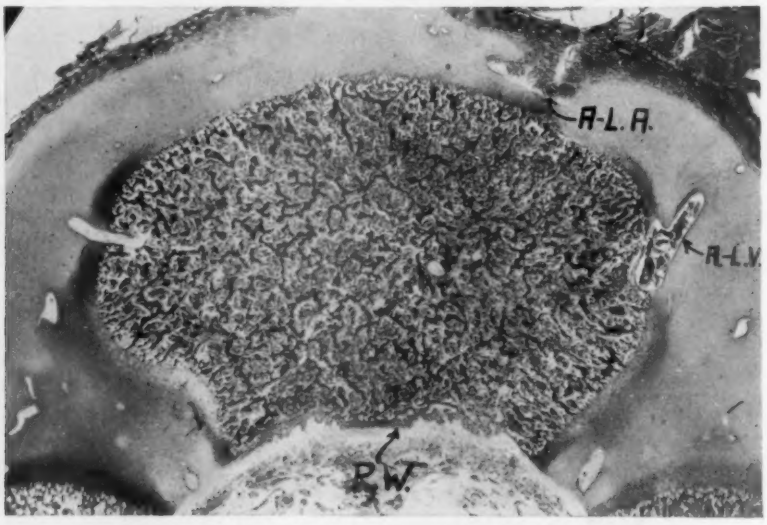

FIG. 8. (H-1. 13×. Hansen-Bock stain). Horizontal section of the lumbar vertebra of a newborn. Section at level below the midpoint of the body. Note uniform texture of the central area. The posterior margin is formed of dense solid bone trabeculae. No such limitation exists at the anterior margin. Two large anterolateral veins are seen entering the body from either side. The lumen of the right anterolateral artery is seen in the upper portion of the photomicrograph.

Fig. 9. (H-2. 13×. Hansen-Bock stain.) Horizontal section through middle of vertebral body. The general configuration of the section is that of a "butterfly" or a "clover leaf." From the central area the bone trabeculae radiate into the lateral masses. Posteriorly the indentation is bounded by heavy trabeculae and divided by a bone septum. The vascular channels are prominent. Note that the central anterior area is bounded posteriorly by heavy trabeculae. No anterior cortical wall is present. Lying within the area is a large sinusoidal space which represents a continuation of the right anterolateral vein. The orifice of the left vein is seen.

tion to the adherent common anterior ligament. In the superior and inferior zones, the calcified cartilage lay in contact with fibrous tissue. In the central zone there appeared an area similar in shape to a truncated cone whose base was ventral and whose blunted apex extended dorsally approximately one-third of the anteroposterior diameter of the vertebral body. No bone trabeculae extended across the base

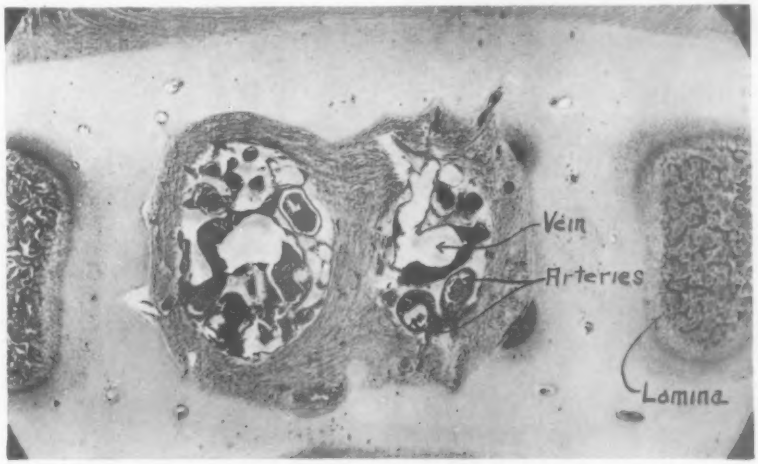

Fig. 10. (C-1. 17×. Hansen-Bock stain.) Coronal section of lumbar vertebra of a newborn. Posterior level. The base of the pedicles are seen as cut bone. In the center of the illustration is the opening of the "posterior notch." The periphery of the opening is surrounded by fibrous tissue which also comprises the central septum, dividing the orifice in two. The lumen of one large vein and two smaller arteries are seen in each of the two halves of the posterior orifice.

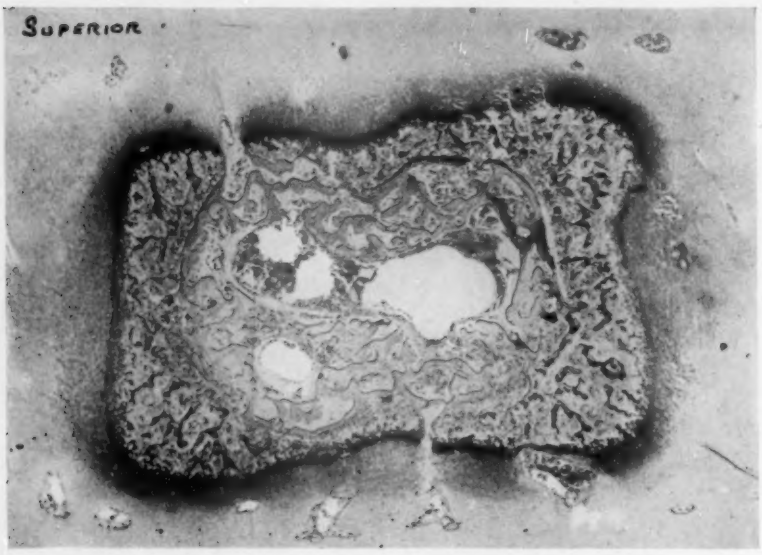

FIG. 11. (C-2. 17×. Hansen-Bock stain.) Coronal section at a level more anterior than C-1. The large open space in the center of the section marks the presence of the central venous sinusoid. The arrangement of the bone trabeculae about the sinusoid is of interest. Note that the vertical extensions of the sinusoids extend into the contiguous intervertebral discs.

of this conical area but trabeculae bounded the sides and blunted end. Within the area were found large sinusoidal spaces lined with a single layer of endothelial cells and into it projected arms of bone marrow.

As succeeding parasagittal sections were examined, this conical area diminished in size until it disappeared. In its place, bone trabeculae appeared, and these, with preosseous tissue, joined the fibrous layer and formed a definite bony anterior wall for the central zone of the body.

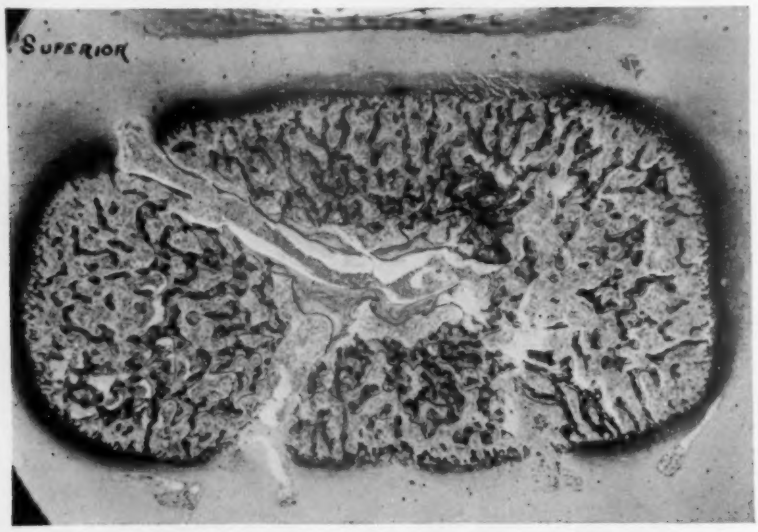

FIG. 12. (C-3. 17×. Hansen-Bock stain.) Coronal section at the level of mid-vertebra. The central sinusoid is seen in the center of the section. Four large spaces are seen extending vertically into the superior and inferior cartilage and intervertebral discs. These vertical extensions and the central sinusoid form an H-like figure.

In the horizontal plane, the conical area likewise diminished in extent and finally disappeared as the sections approached the circumference of the body.

In the coronal plane, the roughly circular area of the cone lessened in diameter and finally disappeared as the sections approached the center of the body.

Thus it is seen that a definite structural difference existed between the central and the superior and inferior zones of the vertebral body due to normal growth was not the sole cause of the appearance of anterior "notching." The chief cause for this appearance was the presence, in the middle segment of the anterior wall, of two portions of the intrinsic vasculature of the body.

1. The vertebral body sinusoid was most prominent, not only in the middle horizontal third of the body, but particularly in the anterior portion of this segment. Its

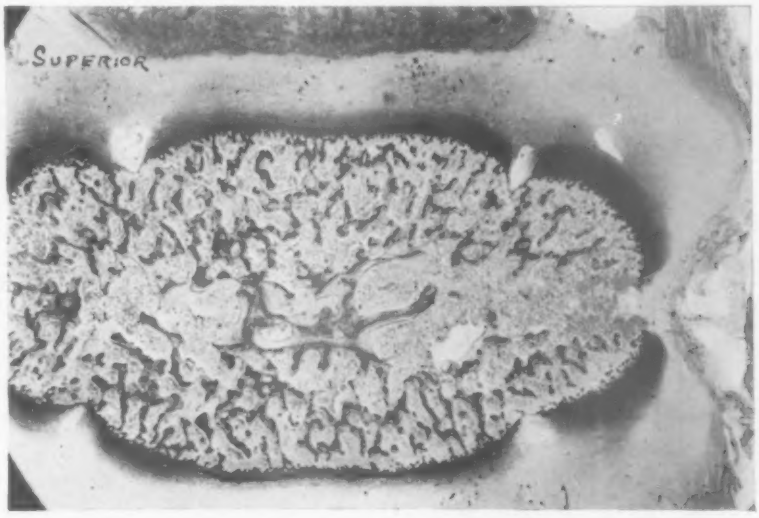

Fig. 13. (C-4. 17×. Hansen-Bock stain). Coronal section of the anterior third of the body. Note that the body is divided into three transverse zones. The upper and the lower zones are relatively dense bone. The central zone is composed chiefly of sinusoidal contents. This zone is divided into three areas by vertical partitions. The middle area is composed of large bone trabeculae and marks the position of the apex of the "anterior notch."

bral bodies. Furthermore, it is shown that in sagittal section, the anterior portion of the central zone differed radically from the posterior portion.

Such structural differences of the several parts of the vertebral body in early life resulted in a differential of roentgen-ray permeability, and in doing so, produced shadows which appeared as (1) a central band of lessened density extending horizontally from before backwards;* and (2) as apparent "notching" of the central portion of the anterior wall when viewed laterally.

The difference in structure of the vertebral body

* To be considered in a third paper now in preparation.

prominence in the anterior portion of the segment was due to the presence at this site of two large arteries and two large veins, which entered it through the anterolateral wall.

2. The two arteries which entered and the two veins which emerged from the vertebral sinusoid were found to do so in the newborn at a point somewhat more anterior than was the case in later life. Furthermore, the point of junction between the arteries and the sinusoids and the veins was more distended in early life than later. These factors, accounting as they did for an unusually large proportion of vascular tissue in the anterior portion of the verte-

bral body, increased the appearance of "notching" by being more permeable to the roentgen rays.

It is therefore seen that the appearance of anterior "notching" is due to structural difference of the anterior portion of the vertebral body; first, of the osseous and pre-osseous structures and second, of the vascular content of the body. The appearance of anterior "notching" is not permanent. It disappears with ossification of the anterior and lateral walls of the body and with the replacement by marrow tissue of the unusually large sinusoidal area occupying the anterior-middle zone of the vertebral bodies of infants.

CONCLUSIONS

In lateral roentgenograms of the vertebral bodies of infants there occur shadows which would seem to indicate the presence of a "notch" or indentation in both the anterior and posterior walls of the bodies.

1. The posterior "notch" shadow results from the presence of an actual indentation in the posterior wall of the body. This indentation is present in all vertebrae and at all ages. The notch is the point of entrance and emergence of the posterior arteries and veins.

2. The anterior "notch" shadow results from the presence, in this area, of a large sinusoidal space within the vertebra. Indentation or "notching" of the anterior wall of the vertebral body is not present.

DISCUSSION

Dr. Ralph S. Bromer, Bryn Mawr, Pa. I am called upon to substitute for Dr. Davis, who as you all know has done much work on epiphyseal development, and for Dr. Batson, the anatomist who is well known to members of the Society. I am sure he would have discussed this paper from an embryological standpoint which would have been very interesting and which would have been of great benefit to us all.

I really have nothing to say except to compliment Dr. Wagoner and Dr. Pendergrass on their study. Köhler and other authorities have discussed this anterior notching, calling it normal, but all explanations have been conjectural in nature. The authors have given an explanation of this finding, determined by them after very careful study. When the pediatricians now ask us as roentgenologists, "What is the explanation of the notching?" we can answer them. We have certainly a very scientific and very careful study on which to base our answer and which fulfills all the criteria of which Dr. McFarland spoke in his Caldwell Lecture last evening. I want to thank both Dr. Pendergrass and Dr. Wagoner for this new explanation of a hitherto undefined roentgen finding.

Vol. 42, No. 5

MADELUNG'S DEFORMITY

CONSIDERATION OF ITS ROENTGENOLOGICAL DIAGNOSTIC CRITERIA

By MAX DANNENBERG, M.D., *Attending Roentgenologist, Beth-El Hospital,* JOSEPH I. ANTON, M.D., F.A.C.S., *Associate Attending Surgeon, Beth-El Hospital, and Cumberland Hospital, and* MILTON B. SPIEGEL, B.S., M.D.
BROOKLYN, NEW YORK

ALTHOUGH the subject of Madelung's deformity has appeared in the literature spasmodically since its original description[8] as an entity, many questions regarding its frequency, etiology, symptomatology, and particularly diagnostic criteria, remain unanswered. The purpose of this communication, besides that of reporting a typical example of the deformity, is to present the important roentgenological diagnostic criteria of this condition. For a more detailed description of the historical background and clinical picture, and discussion of the etiological pathogenesis, the reader is referred to an exhaustive paper on this subject written by the authors (Anton, Reitz and Spiegel[1]).

Madelung's deformity is an uncommon affection of the wrist, characterized by local changes in the configuration of the radius, with an instability of the distal radio-ulnar articulation. Any abnormalities of the ulna, carpal bones, articular cartilages, ligaments, and tendons about the joint, are all of a compensatory nature, secondary to the radial deformity itself. Although the actual pathogenesis remains cryptogenic, the etiology of the deformity seems to be that of a "dyschondroplasia of the distal radial epiphysis." This process gives rise to an idiopathic progressive curvature of the radius, resulting in a bayonet-shaped deformity of the hand at the wrist, somewhat as if there were an anterior dislocation of the hand. In rare "reverse" type of the deformity, only 5 cases of which have been reported,[4,5,7,10,14] the palmar deflection of the lower end of the radius is reversed and the bowing is therefore anterior.

In our previous paper,[1] 171 cases of the deformity were tabulated, and since that time we have found no other cases of the condition reported—making our case report below the 172nd acceptable report of the affection in medical literature, the 22nd to be reported from this country.

The deformity is usually bilateral (128 of 172 cases), is practically always noticed in adolescence, and is far more frequently found in the female (4 to 1). Several cases of hereditary influence have been reported, and also several instances of association with other osseous anomalies. Our own patient is markedly small for her age, a condition which has coexisted in several previously reported cases. Weakness and insecurity, and sometimes pain, in the affected wrist is complained of, especially at the inception of the deformity. Motility at the joint is modified by the disturbance of mechanical factors. Extension and abduction are restricted, and sometimes adduction also. Flexion is frequently augmented. Pronation and supination are variably limited. The head of the ulna projects prominently at the back of the wrist, and the hand and carpus appear to be dislocated anteriorly. The projecting luxated end of the ulna may sometimes be reduced into its radial articulation, but it returns immediately on release of pressure. The forearms are occasionally obviously shorter than normal.

The previous history is important in bringing out the absence of any local trauma to the wrist, and the existence of rickets as a causative factor must also be eliminated. In the report of our previous case,[1] "in view of the fact that the patient presented no menstrual disorder, nor any other evidence of a hormonal upset, it was not deemed necessary to undertake the laborious and complicated determinations

of the various sex hormones." However, our present patient presented so many stigmata of sexual retardation, despite having attained the age of puberty, that such determinations were undertaken, revealing an entire lack of prolan or estrin. Outside of this, no other abnormalities have been revealed by a complete urinary, hematological, serochemical, and metabolic study of the patient. Similar results were obtained in our previous patient, confirming the reports of several authors.

CASE REPORT*

Ana S., a white female, aged thirteen, was admitted to the hospital complaining of fever, migratory joint pains, epistaxis and pharyngitis. The family history is negative. The patient was delivered in a normal spontaneous labor, and has been entirely normal in her development except that she has been underweight and undersized since infancy. At the age of four, she contracted measles and chickenpox. There is no history of any other medical or surgical diseases, nor any history or evidence of any local injury to the wrists. She has not engaged in any particular occupation which might account for her deformity. She is active, mentally alert, and indulges in the usual exercises or play for her age. There is no history or evidence of the onset of the menarche.

Twelve days before admission, the patient suffered a bilateral, spontaneous epistaxis, followed two days later by an upper respiratory infection, associated with a temperature of 102° F. During this febrile state the patient was seized with migratory joint pains, not associated with swelling or redness of involved joints.

Physical examination reveals a poorly nourished, underdeveloped female child, small in stature for her age, and presenting a pale, sallow complexion. She is mentally alert, cooperative, and not apparently suffering from any discomfort. The breasts are underdeveloped, and there is an absence of pubic and axillary hair, showing a lack of secondary sex characteristics. The only abnormal findings in chest or abdomen are those pointing to a rheumatic heart—P^2 accentuated, loud systolic murmur at the base transmitted over precordium along the left sternal border toward the nipple; the heart is not enlarged and the electrocardiogram is normal except for sinus arrhythmia. The organs of special sense, and the abdominal and remaining thoracic viscera are all apparently normal and there are no sensory, trophic, or vasomotor disturbances. The visible mucous membranes are of pale color, and the teeth are in poor repair.

The patient is 51 inches tall and weighs 56½ pounds. The skeletal system presents no objective findings of rickets. The head is well formed without any evidence of craniotabes or frontal or parietal bossing. The thorax is symmetrical, without any signs of scoliosis, rickety-rosary, or Harrison's groove. The pelvis is normal in configuration, but small in size. The hips and knees are normal and the tibiae are perfectly straight. There is no broadening of the epiphyses.

On examining the upper extremities, one is struck with a peculiar bilateral bayonet-shaped deformity of the wrists, resembling an anterior subluxation of the hands. The marked prominence of the ulnar styloid gives rise to a swelling at the back of the wrist. A decided shortening of both forearms is noted, with an apparent increase in the lateral curvature of the radius. Motility at the wrist is affected only slightly, and the limit of motion from a horizontal plane is estimated as:

	Right	*Left*
Flexion	95°	95°
Extension	70°	80°
Adduction	45°	40°
Abduction	10°	5°

Pronation and supination within normal limits.

A complete chemical, biochemical, endocrine, urinary, and hematological study was made on the patient, as had been carried out by several previous authors. A study of the results obtained by them indicate that this condition is not manifested by any deviation of the body's chemical or biological processes as would be indicated by a biochemical test. Our own findings, recorded below, tend to confirm that impression.

Hematological: Hemoglobin 72 per cent (Sahli); red blood cells, 4,300,000; white blood cells, 9,400; differential—polymorphonuclears 74 per cent, lymphocytes 26 per cent. The sedimentation rate varied with the progress of the acute infection. Blood cultures were negative.

Urinalysis: No abnormalities.

Feces: Negative for ova, parasites, or pathogenic bacteria.

* From the Pediatric Service of Dr. Abraham M. Litvak, Beth-El Hospital, Brooklyn, New York.

Blood chemistry:

Urea nitrogen	16.7 mg. per 100 cc.
Glucose	87.0 mg. per 100 cc.
Albumin	4.8 mg. per 100 cc.
Globulin	1.3 mg. per 100 cc.
Total proteins	6.1 mg. per 100 cc.
Calcium	12.8 mg. per 100 cc.
Phosphorus	3.4 mg. per 100 cc.
Cholesterol	201.0 mg. per 100 cc.
Cholesterol ester	98.0 mg. per 100 cc.

Endocrinologic: Basal metabolism estimated at −5 per cent. Estrogenic determination: follicular hormone—no rat units; follicular stimulating hormone—negative. Roentgenograms of the sella turcica reveal no abnormalities.

The exact nature of the deformity is revealed in a careful roentgenographic study of the local lesion, as described below: "Roentgenographic examination of the forearms shows a bilateral bowing of the radius on the outer and dorsal aspects. The radius is relatively shorter than the ulna. The epiphysis of the radius is triangular in shape and outline with the apex pointing medially where there is a tendency to early fusion with the diaphysis. The articular surface of the epiphysis of the radius is rotated forward and medially. There is a lime salt absorption of the metaphyseal end of the diaphysis of the radius medially where small osteitic excrescences are noted. There is a widening of the interosseous space between the radius and ulna. There is an upward displacement of the semilunar bone with a resultant pyramid formation of the carpal bones. The ulna is displaced posterior to the semilunar bone. The carpal bones are tilted forward to conform with the dorsal bowing of the radius. There is a hypercondensation of the epiphysis of the ulna. The findings as described above are noted on both sides, and are characteristic of a Madelung's deformity."

Fig. 1. Photograph of the clinical picture of the wrist deformity, showing the swelling at the back of the wrist and the apparent anterior displacement of the carpus.

Fig. 2. Anteroposterior roentgenogram of the wrist.

DISCUSSION OF DIAGNOSTIC ROENTGENOGRAPHIC CRITERIA

Although clinical descriptions of the deformity date back to Malgaigne's report[9] in 1855, necropsy provided the only means of pathological investigation. In 1897, Jagot[6] turned the light of the roentgen rays upon the condition, and it has since fallen mainly to the roentgenologist to clarify its pathology and confirm its diagnosis. Examination of the roentgenograms of other reports, and of this and our previous case, led us to attempt a formulation of the fol-

FIG. 3. Posteroanterior view of the wrist (taken with the hand in pronation).

lowing set of twelve observations to serve as a standard for the diagnostic criteria of dyschondroplasia of the distal radial epiphysis.*

1. A double (lateral and dorsal) curvature of the radius takes place. The lateral curvature has its concavity facing the ulna, and is an exaggeration of the usual normal bowing of the radius. It occurs throughout the entire diaphysis, and should be well marked when the plate is taken with the hand in pronation (posteroanterior). The dorsal curvature is perhaps the most important disturbance of the condition, having the radius bowed with the concavity on the volar aspect, leading to an anterior or palmar bending of the distal end of the radius, usually in the lower third, with the greatest intensity at the epiphysis or metaphysis, sometimes as if the epiphysis itself had rotated (Figs. 2, 3, 4, 5 and 6).

2. There is a variable widening of the interosseous space, due to the lateral curvature described above. This finding is especially obvious in roentgenograms taken in a posteroanterior position, with the hand in pronation (Figs. 3 and 5). When the hand and forearm are roentgenographed in a true anteroposterior position, this widening is not so evident (Fig. 2).

3. Over and above any apparent shortening of the total length of the radius due to the double curvature described above, the radius is usually found to be actually shorter than would be expected, either in comparison with a normal standard for the age, or with the relative size of the remaining skeletal system. The cause of this shortening is in the nature of a chondrodysplasia.

4. The appearance of the distal epiphyseal line has been variously described, but it is quite obvious that, generally speaking, its appearance will depend on the age of the patient. Since this deformity is an affection of adolescence, one would ex-

FIG. 4. Lateral view of the wrist.

* The authors wish to repeat the plea made in their previous article that the term "dyschondroplasia of the distal radial epiphysis" be adopted in place of the nonspecific "Madelung's deformity."

pect some evidence of the epiphyseal line of the inferior radial epiphysis to be still discernible, as it is described as fusing with the diaphysis between the ages of seventeen to twenty.[12] If roentgenograms of this deformity are examined, it is found that a premature fusion has already taken place at the mesial, or ulnar, half of the epiphyseal line (Figs. 3 and 5). The importance of this finding as to its etiological significance has been propounded in our previous article.[1]

5. On the ulnar border of the radius, extending for a short, variable distance above the fused epiphyseal line, is an area of bone apparently showing some lime salt absorption (Figs. 3 and 5). This has been described and emphasized by several French authors,[11] who describe it as a "hemiatrophy of the inferior radial epiphysis." Our previous article regards this rarefaction as a result of decreased blood supply, rather than a retrograde process of decalcification, lime salt absorption, or hemiatrophy.

6. Found along the inferior ulnar border of the radius are small osteitic excrescences, often condensed into a definite exostosis (Figs. 3 and 5). Stetten[15] has described this as "a remarkably frequent finding." Bessel Hagen[3] has demonstrated that any bone which gives rise to exostosis formation undergoes an arrest in development.

Fig. 6. Lateral view, with explanatory figures pertaining to the numbered paragraphs of the text.

7. The roughly quadrilateral-shaped outline of the inferior radial epiphysis undergoes triangularization, with the apex of the triangle pointing medially (Figs. 3 and 5). This triangularization is a result of the premature fusion of the medial end of the epiphysis as described above.

8. The double curvature of the radial diaphysis previously described occurs in such proximity to the wrist joint that it is inevitable that the articular surface of the

Fig. 5. Posteroanterior roentgenogram, with explanatory numbers pertaining to the numbered paragraphs of the text.

inferior end of the radius is affected. Instead of facing directly forward, it comes to face internally (ulnarwards) and downwards (palmarwards). This has been described by Siegrist[13] as a deviation of the joint surface on two axes (Figs. 3, 4, 5 and 6).

9. The bending palmarwards of the lower end of the radius leads to a luxation or subluxation of the inferior radio-ulnar articulation, and the lower end of the ulna will be found to occupy a posterior level to the radius in the lateral views (Figs. 4 and 6). In the rare "reverse" type of the deformity the ulna lies on an anterior plane.

10. Examination of the ulnar head reveals a hypercondensation of the trabeculations. This has also been described by previous authors as a hyperostosis of the ulnar head or styloid (Figs. 3 and 5).

11. The deviation of the inferior radial articular surface inwards leads to a modification of the usual arched arrangement of the carpal bones. The carpus becomes wedged in between the deformed radius and the protruding ulna, assuming a triangular appearance, with the os lunatum at the apex (Figs. 3 and 5). This triangular shape is most obvious when the roentgenogram is taken with the hand in pronation. Bennecke[2] first described this "pyramidalization" of the carpal bones as compensatory to the malarrangement of the component parts of the wrist joint.

12. The lateral roentgenographic view reveals an arched curvature of the carpal bones as a direct continuation of the arc of the posterior bowing of the radial diaphysis (Figs. 4 and 6).

SUMMARY

1. A typical case of Madelung's deformity (dyschondroplasia of the distal radial epiphysis) is reported.

2. Twelve diagnostic roentgenographic criteria are formulated as a guide in the diagnosis of this condition.

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Vol. 42, No. 5

THREE-PHALANGEAL THUMBS

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CONGENITAL anomalies may be due to a number of causes such as a disturbance in the normal, orderly development of the embryo, an abnormal proliferation of developing tissue, excessive or monstrous development, or an injury *in utero*. They may also be considered as an atavistic characteristic.

The anomaly in which an individual has three thumbs presents a condition that offers a field for special study from an embryological and anatomical standpoint.

The normal adult thumb consists of one metacarpus and two phalanges. In comparison with the other fingers, it therefore has one less phalanx and joint. In seeking an explanation for this difference, one naturally turns to comparative anatomy for some reasonable explanation. It was expected that some clue would be obtained in the lower primates, but unfortunately no material of any value was found. Not until the class of Reptilia is reached is there any possibility of an explanation. In the reptiles there are more than two rows of tarsal and carpal bones, so one might theorize that the first metcarpal is represented by one of these carpal bones. Of course, the fins of fishes show a multi-ray arrangement, but one is disappointed in not finding some of the higher forms of Vertebrata with a three-jointed thumb and a gradual metamorphosis from the lower forms of animal life.

If attention is now directed to the study of the normal growing thumb, some interesting facts are found in respect to the epiphyseal cartilage plates. Unlike the long bone, the phalanges and metacarpals possess but one epiphyseal cartilage plate. (There are occasionally two epiphyseal plates in the first metacarpal and at the base of the fifth. The phalanges may, in some instances, have two epiphyseal plates.) With the exception of the thumb, the epiphyseal plate of metacarpals is at the distal end. All phalanges have the epiphyseal plate at the proximal end. The first metacarpal differs from the other metacarpals in that the epiphyseal plate is at the proximal end just like the phalanges.

Because the first metacarpal has the epiphyseal plate at the base, Galen, Vesal, and others maintained that it was a phalanx. The first metacarpus would then have to be represented by a carpal bone or, in the process of evolution, disappear entirely.

It is claimed by others that the first metacarpal is a true metacarpal. In support of this view is the findings of three-phalangeal and three-jointed thumbs. The persistence of the extra phalanx is considered as a retrogressive step in development. Another supporting fact that the first metacarpal is a true metacarpal is the finding of a similar muscle arrangement of this metacarpal to that of the others. The occasional finding of two epiphyses on the first metacarpal offers the possibility of an adaptive maintenance of the one epiphysis.

Having just briefly touched on some of the problems of the development of the thumb, we will now direct our attention to the study of three-phalangeal thumbs. Although the reported cases are rather few, the occurrence is not so uncommon. Four families were encountered recently in which one or more members presented this phenomena. Salzer, Groeschel, Joachimsthalium, Staderini, and Rieder have reported cases with this anomaly. Groeschel's patient had three phalanges on both right and left thumbs, the phalanges being well developed. Salzer's patients also had three phalanges on both thumbs. The mother of his patient likewise had three-phalangeal thumbs and the sister had a disturbance in growth of the hand. Joachimsthalium and

FIG. 1. Family I. Three-phalangeal thumb, left hand. Ulnar deviation of distal phalanx.

Rieder's patients had a combination of the extra phalanx on one side and a short finger on the other hand.

The explanation of this extra phalanx has led to considerable discussion. It seems that the most plausible one is that normally the extra phalanx is assimilated by the distal phalanx and that when it is not, there is an extra phalanx and joint. It is held by some that the extra bone is the separation of a distal epiphysis of the second phalanx. If it were a separated epiphyseal end of the second phalanx, an epiphyseal plate should be found at its distal end, a finding which has not been reported.

It is claimed by some investigators that the three-jointed thumb represents an extra index finger and that there is an absence of the thumb.

A report of the findings in three families of extra-phalangeal thumbs will now be presented. Malformations of the hand in other members of the family will also be discussed.

FAMILY I.

Family History. One son admitted to the Shriner's Hospital on account of deformity of the hands. There was an absence of thumbs on both hands.

Mother's Examination. There were three joints in the thumb on the left hand. Roentgenograms (Fig. 1) showed an extra phalanx in this thumb. The extra bone was short with irregular articular surfaces. The first metacarpal was thinner than normal. There are only two well-formed bones in the proximal row of carpal bones. The radial styloid is poorly developed. The middle phalanx of the fifth finger

FIG. 2. Family II. A. McC. Showing three-jointed thumbs on both hands.

is more irregular and smaller than normal. There is no evidence of an extra phalanx or other anomalies of the thumb of the right hand. The distal phalanx is not longer than normal and shows no evidence of assimilating an extra bone.

Comment. In this family there is a son with failure of development of thumb of both hands. The mother has an extra-jointed thumb. One should look for this anomaly if there are abnormal hands in other members of the family.

Fig. 3. Family II. A. McC. Roentgenogram showing the three phalanges. Note the duck-bill appearance of the distal phalanx. The end phalanx is in radial deviation.

Family II. A. McC., female, aged seven and a half.

Complaint. Deformity of the thumbs.

Family History. Mother, paternal grandfather, and aunt have three joints on thumbs. One brother, aged six, has a broad, flat thumb nail. One brother has extra joints on thumb.

Present Deformity. At birth it was noticed that the patient had a deformity of the thumb. There has been no change during the growing period except a radial deviation of the distal phalanx. There is no apparent deformity of the lower extremity.

Examination. There is a radial deviation of the distal end of both thumbs (Fig. 2). No evidence of any other abnormality of the body was found. There is an extra joint on both hands with definite movement in the extra joint. Roentgenographic examination (Fig. 3) shows no abnormality of the carpal bones. The thumb or first finger of both hands is made up of the usual type of first metacarpal with a single epiphysis at the proximal end. The first phalanx is of the normal type for the thumb. The second, or extra phalanx, is wedge shaped. There is no epiphyseal plate at either end. There is a small area about the middle which may be an ossification center. The third, or distal phalanx, has a definite basal epiphysis which is slightly irregular as is its epiphyseal cartilage plate. The distal end of the bone has a peculiar, duck-bill appearance. This may be considered as an incomplete division, a tendency for bifurcation, or the early stage of development of an accessory thumb.

Brother of patient, aged six. The mother stated that he had an abnormally broad, flat thumb nail but no extra joint.

Examination showed a definite extra joint of which the parents were unaware. The thumb

FIG. 4. Family II. Brother of A. McC. Three-phalangeal thumbs on both right and left hand. Duck-bill appearance of distal phalanx and division of the second phalanx.

nail is broader than normal. There was a little inward deviation of the distal end of the thumb.

Roentgenogram of brother (Fig. 4): The metacarpals of the right hand show an extra rudimentary epiphysis at the distal end. This epiphysis is slightly irregular and the epiphyseal plate is also irregular. On the left side there is a suggestion of a distal epiphyseal plate, but it is not complete and may be undergoing fusion. The first phalanx on both sides appears normal. The extra, or second, phalanx is irregular in outline. The one on the right is composed of two segments. That on the left is irregular, but there is no separation of the two. The distal phalanx has the peculiar duck-bill appearance, but the division is not so distinct as in the sister. This partial bifid appearance of the distal phalanx with the definite division of the extra phalanx (right) lends itself to the suggested theory that it is an incomplete attempt at the formation of an extra thumb. The broad thumb nail with a ridge down the center may represent an aborted attempt at division.

Mother. The mother had an abnormally broad thumb nail with a peculiar streak down the middle of the nail. The distal phalanx was abnormally long.

Roentgenogram of mother (Fig. 5): The carpal bones appear normal, showing the first metacarpal bone a little shorter than normal. The first phalanx appears normal. The distal phalanx is longer than normal. It shows the duck-bill appearance as in the two children. The proximal end is somewhat irregular. On the right there is an incomplete fusion extending half way across the bone. On the left there is a slight suggestion of a fusion line. This appearance tends to support the theory that the extra phalanx in normal development becomes fused to the distal phalanx.

Family Tree. Paternal grandmother and aunt have three-jointed thumbs. Grandmother's thumb turned out like A's. Aunt: Three-jointed, straight thumbs, reaching to second joint of index finger when held side by side. One son: Curved, three-jointed thumbs like A's. One son, patient's grandfather: Long, flat, two-jointed thumbs with ridged thumb nails split lengthwise in center. Grandmother's sister:

Fig. 5. Family II. Mother of A. McC. Note the long distal phalanx of duck-bill type. There are signs of fusion of what was probably an extra phalanx.

Fig. 6. Family III. Three-phalangeal thumb of a six-fingered individual. Dichotomous condition of proximal phalanx, left hand. Duck-bill form of distal phalanx, right hand.

Three-jointed, curved thumbs, like A's and six toes. Grandmother's sister's son: Long double thumbs joined together making one large, flat thumb with deep line through the middle.

FAMILY III. A more recent case was encountered in the course of the study of a syndactylized, six-fingered boy. The mother stated that she was born with six fingers on both hands. Three fingers were syndactylized. One of the extra fingers was removed and the syndactylism also treated by operation.

Examination. There were three joints on both thumbs. The roentgenograms (Fig. 6) showed the presence of six metacarpal bones on both hands. There are three phalanges in the thumbs on both sides. The distal one on the right is somewhat of the duck-bill type. The distal end of the first phalanx is bifid. The second metacarpal has not developed or has been partially removed on both sides. There is an extra carpal bone corresponding to the extra metacarpal.

Good roentgenograms were not obtained of the baby, but there seems to be an extra phalanx on the thumb. Later study will be interesting when the fingers can be separated for study.

DISCUSSION

The cases just presented provide some interesting material from which one may obtain clues as to an explanation of the normal structure of the thumb and the abnormal formation of the extra-phalangeal thumb.

In the case of the mother of A. McC. there is evidence of the assimilation of the extra phalanx by the distal phalanx. In the family McC. several members had the peculiar bifid, or duck-bill formation, of the extra phalanx, also in the extra phalanx a tendency for longitudinal division. In another family (Family III), this patient had a three-phalangeal thumb, and the phalanx of one thumb had a duck-bill structure. On the other hand, the proximal phalanges showed a partial division (dichotomy). Because of this tendency to bifurcation of the end phalanx in several of the three-phalangeal thumbs, and the finding of an extra phalanx in a six-fingered individual, also with a duck-bill distal phalanx and a dichotomous, proximal phalanx, it is offered as a theory that the formation of the extra-phalangeal thumb is an arrested atavistic attempt to form an extra finger. It would be interesting if one could find, for a comparative study, some of the lower animals above the fishes in which there were more than five digits.

CONCLUSIONS

1. The histories of three families are reported in which one or more individuals had three-phalangeal thumbs with three joints.

2. The findings here suggest that in the normal, developing thumb the extra phalanx is assimilated by the distal phalanx. The first metacarpal is considered as a true metacarpal with an undeveloped distal epiphysis.

3. There was a peculiar duck-bill appearance of the end phalanx in several patients, a separation of the extra phalanx and other evidences of attempts at division.

4. The explanation offered for this anomaly of a three-phalangeal thumb is that it may be an arrested attempt to form an extra thumb.

Vol. 42, No. 5

UNILATERAL ENLARGEMENT OF THE LOWER EXTREMITY ACCOMPANYING VARICOSE VEINS

WITH ROENTGEN STUDIES OF "DEEP VENOUS BLOCK"†

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UNILATERAL enlargement of the lower extremity accompanying varicose veins has not been adequately studied. In the presence of evident varicosities the condition is familiar and well understood. However, when the hypertrophy persists in spite of thorough injection treatment, a problem presents itself. Too often the nebulous term "deep venous block" has been assigned to these cases. It is the purpose of this paper to clarify this condition and present new modes of therapy based upon physiological principles.

TECHNIQUE

The method employed in this study is simple. It consists of injecting a radiopaque solution into the veins for the purpose of visualizing the venous tree.

Certain precautions should be observed with this technique. It must be remembered that irritants are being injected, and it is quite possible to light up a quiescent phlebitis. The resulting reaction may be dangerous. Patients giving a history of phlebitis should be tested with one or two sclerosing injections before attempting roentgen examination.

The solution used in these studies is diodrast,* which contains iodine in its chemical makeup. This preparation is aqueous, flows readily through the average needle and has proved to be non-toxic. It throws clear shadows even after dilution with blood, provided it remains relatively localized in the vascular channel.

A superficial vein anywhere on the leg is selected and 10 to 20 cc. of diodrast is slowly injected with the patient standing. Following this, a tourniquet is immediately applied above the knee in order to obliterate the great saphenous and other superficial veins. The patient then lies down quickly, and two views are taken: an anteroposterior and a lateral. Then the tourniquet is released.

It has been found that the best roentgenograms are obtained in the worst cases of venous enlargement. As the rapidity of the blood stream increases to normal, the dye is localized with greater difficulty. With a normal venous tree no shadows will be obtained unless the exposure is made while the solution is being injected.

This method was employed in three types of unilateral hypertrophy. They will be discussed under the following headings:

1. Enlargement due to varicose veins.
2. Enlargement as a result of lymphatic block.
3. Enlargement following deep venous thrombosis.

1. *Enlargement Due to Varicose Veins.* Obvious enlargement due to varicosities of the superficial venous system is too well known to merit discussion. It is illustrated in Figure 1. Injection treatment always results in a normal limb comparable with the sound one.

In the absence of visible varicosities, the simplest type of unilateral enlargement is due to the dilatation of the communicating system of veins. These so-called "blowouts" may often be suspected before beginning treatment by the Trendelenburg test. The superficial venous channels are emptied by raising the extremity with the patient in a sitting position. One finger is then placed upon the saphenous opening

* Diiodopyridon acetic acid diethanolamine (Iopracyl) Winthrop.

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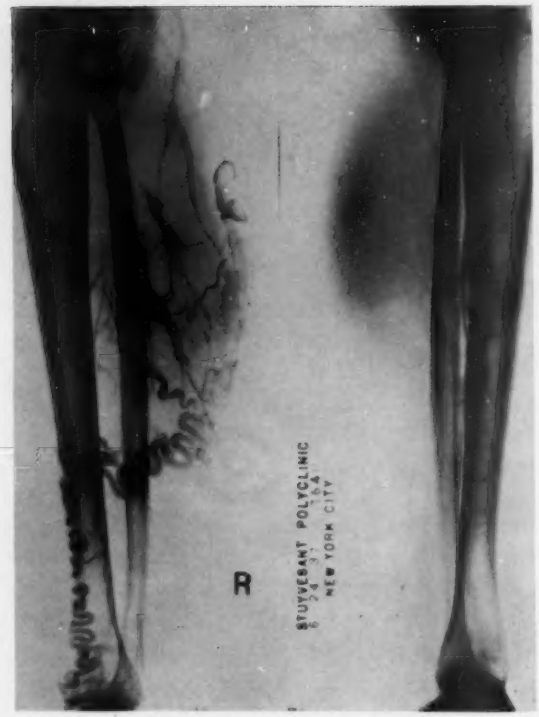

FIG. 1. Right side illustrates uncomplicated varicose veins. The deep veins are straight, and the popliteal is visualized as a patent large vessel. On the left side, note the poor visualization in the normal extremity.

and the limb is lowered while the pressure is maintained. "Blow-out" areas are indicated by a sudden filling within thirty-five seconds which is localized to one area. This is called a negative reaction, and indicates filling from within, due to incompetence of the communicating veins (Fig. 2).

The comparative tourniquet test of Mahorner and Ochsner[7] ensures more accurate determination of the competency of the valves in the communicating veins of the thigh. It does not, however, add anything to the information furnished by the Trendelenburg test in cases with communicating vein incompetency below the knee.

Inspection and palpation alone will sometimes suffice for diagnosis. A pouching-out of the veins in a localized bulge which springs back after pressure is often a good diagnostic sign. With experience, the "feel" of this phenomenon becomes recognizable, and then the roentgen ray can be used for confirmation. Injection treatment is simple when the condition is recognized.

2. *Enlargement as a Result of Lymphatic Block.* The obvious type of unilateral enlargement due to superficial varicosities has been discussed. It has also been shown how invisible communicating enlargements may be demonstrated roentgenographically. There is another type of hypertrophy which results from disturbances in the lymphatic system and is less readily recognized.

Many years ago, Cruikshank[4] demonstrated the intimate anatomical relationship between the venous and lymphatic vessels of the lower extremities. It was apparent that an infection starting in one system could affect the other. Experi-

FIG. 2. Phlebography in a case of incompetent communicating veins of the leg. The deep system is normal and the popliteal vessel is plainly visualized. Note the tibial vein.

mentally, it was proved that simple ligation, even of important venous channels, would not cause hypertrophy of the limb. Workers demonstrated, however, that direct lymphatic obstruction would cause enlargement of the lower extremity.[5] It remained only to prove that artificial phlebitis of the femoral vein could cause a lymphatic block with subsequent enlargement by direct extension of the infection.[6] The picture was complete, and the relationship of phlebitis to lymphedema became clear.

A special type of lymphedema which is often neglected should be mentioned here. In 1936, I described a new clinical entity, "Lymphedema Occurring with Varicose Veins."[1] This particular type of lymphedema presents a serious problem because of its frequent association with latent varicophlebitis. The other types of origin are, however, also important and must be briefly enumerated.

The tropical type of lymphatic obstruction known as elephantiasis is an example of lymphedema caused by direct invasion of the lymph channels by filarial organisms. The skin has been shown by Castellani[3] to be the starting point of a pseudo-elephantiasis due to infection by an organism which he isolated and called *Streptococcus* (*Micrococcus*) *myceticus*. Lymphedema may also follow trauma which occurred years previously due to traces of infection which have been left in the lymphatics. Congenital lymphatic disorders, such as Milroy's disease and congenital lymphangiectasia, are due to abnormal development of the lymphatic channels which induce stagnation of flow.

It is clear that chronic lymphostasis may arise from a variety of causes. The pathology of chronic lymphangitis is present in all of these cases. It may take years for enough obstruction to occur to cause symptoms of enlargement. It is not surprising, therefore, that this condition in its early or local stage, especially when accompanied by skin changes, is often erroneously diagnosed or missed completely.

Complications often attend chronic lymphostasis which must be recognized. The cases in which the limb shows only a diffuse enlargement without trophic changes are infrequent. Usually, a hard, non-pitting edema develops locally and soon discoloration occurs. The color changes are due to rupture of capillaries with resulting blood pigment decomposition. The discoloration varies from light purple or brown to a dark blue or even black. Pathologically, the determining change is a fibrosis which chokes off capillary as well as lymphatic circulation. This skin which is undernourished becomes rough and elephant-like. It may assume the appearance of a dermatitis or eczema. Ulceration may occur, and once developed, often becomes intractable unless specially treated, as will be described later.

The lymph block may be either central or peripheral. The central type sometimes follows post-partum milk leg or postoperative femoral phlebitis. The peripheral type occurs with infection above the fascia as in the case of wounds, cutaneous infections and phlebitis of either normal or varicose superficial veins. Skin changes occur most readily in the localized peripheral types. However, cases starting as central lymphatic blocks often show, as the signs progress, changes in the subcutaneous tissues peripherally. In extreme cases, without proper care, especially in aged individuals, the ulceration may become gangrenous and simulate arterial disease. However, oscillometric tests will quickly and clearly indicate the lymphatic origin of this type of gangrene.

The diagnosis of enlargement due to lymphostasis is not always simple. Usually, the character and color of the edema will aid in the establishment of the condition. This may vary from a simple, colorless, brawny induration to a pigmented sclerotic or even contracted leg accompanied by skin changes or ulceration. The edema is always non-pitting and has a characteristic "feel."

There are cases, however, with a central femoral lymphostasis in which there has been no fibrosis. These early cases may

FIG. 3. Phlebogram of Case I, with a history of post-operative phlebitis. Note decrease in the size of the tibial and popliteal vessels. The small deep veins show extensive tortuosity, indicating collateral formation.

present only a peculiar turgor which is elastic and non-pitting. This variety of lymphedema is difficult to diagnose, and may require roentgenography to be established by exclusion (see Case III, Fig. 5).

The history is extremely important in this disorder. Every case with hypertrophy of the lower extremity should be questioned regarding any previous occurrence of phlebitis. This may have taken place up to twenty years previously, and the patient may have completely forgotten the incident. Insistent questioning, however, may disclose a phlebitis following pregnancy, surgery, trauma, or some constitutional disease. In many cases, this has apparently healed so that the connection with the existing enlargement is vague.

In cases of varicose veins, there may be no history at all to clarify the issue. In these cases of lymphatic enlargement, the pathology is due to a chronic varicophlebitis with a subsequent lymphangitis of an indolent nature.[2]

Treatment has been described elsewhere.[1] Briefly, it consists of obliterating any varicosities that may be present. Subcutaneous injection of isotonic mixtures through large bore needles will encourage the growth of new capillary and lymphatic vessels. Massage is a useful adjunct to this treatment. Cataphoresis with vasodilating drugs often assists in healing the ulcers in these cases. Rest, bandaging, or medicinal treatment is of no avail, except as palliative measures.

The prognosis depends upon the amount of hypertrophy and the degree of fibrosis. Localized lymphedema can usually be cleared up with persistent treatment. Elephantiasis involving the whole limb can be relieved, but as yet, not completely restored to normal.

3. *Enlargement Due to Deep Venous Thrombosis.* It has been accepted that following deep phlebitis of the lower extremities, a condition of deep block often remained which caused permanent swelling of the limb. A special test devised by Perthes was supposed to aid in its diagnosis. By placing a tourniquet above the knee, the great saphenous vein was obstructed. Then the patient was instructed to walk or trot. Any increase in prominence of the superficial venous system was accepted as an indication of deep venous block. In the presence of superficial varicosities, injection treatment was contraindicated.

In recent years, some clinicians have been discarding this test because of the absence of positive reactions. My own negative findings led me to suspect the existence of a fairly adequate deep circulation. Roentgenographic studies were instituted in a series of cases exhibiting hypertrophy where previous deep thrombosis had occurred or was suspected. A few typical cases will be described.

CASE I. M. S., aged forty, female, when first seen exhibited medium-sized varicose veins bilaterally. The left lower extremity was enlarged 25 per cent. Suprapubic varicosities were present.

Eighteen years ago, she was operated on for

uterine fibroid. She developed a postoperative phlebitis of the left lower extremity, and remained in the hospital two months. Since then, the leg has been enlarged. It was soft, compressible, and showed no evidence of lymphatic stagnation. The roentgenogram (Fig. 3) shows a decrease in the size of the deep veins with an extensive deep collateral circulation. The collaterals are very tortuous in character. This is a case of deep thrombosis with a new growth of collateral veins.

Case II. L. K., aged forty-five, female, was treated for a few small superficial varicose veins. In spite of this, the left lower extremity remained large. It felt heavy and was sensitive to cold. She was operated on twice. The first operation, ten years ago, was for myoma of the uterus. She had four children, and had a definite post-partum phlebitis after the first pregnancy. During the subsequent three other pregnancies, and up to the present time, her leg has remained swollen.

Fig. 4. Roentgenogram of Case II, with a history of post-partum phlebitis. The popliteal and tibial vessels are small. There is an extensive deep collateral network. Note the scarcity of normal straight venous channels.

Fig. 5. Roentgenogram of a leg with extensive lymphedema and a few superficial varicosities. Note the normal tibial and popliteal veins. This plate excludes the diagnosis of deep thrombosis.

There was no hardness to this swelling. The roentgenogram (Fig. 4) discloses very numerous tortuous collateral deep veins. There is no definite main popliteal vein. This is an indication of previous deep venous thrombosis with the establishment of a new deep venous bed.

Case III. L. K., aged forty-five, male, when first seen exhibited an enlarged left lower extremity. The leg was tremendously enlarged,

approximately 50 per cent. There was a moderate number of varicosities present on both legs.

He gave a history of swelling for sixteen years. He had a fractured skull fourteen years ago, which necessitated hospitalization for ten weeks. Examination was negative, except for a peculiar generalized cyanosis. There was no sign of arteriovenous aneurysm.

A biopsy was obtained from the skin and subcutaneous tissues. It showed only fibrosis. The blood and urine were negative. The roentgenogram (Fig. 5) showed superficial varicosities, an open popliteal vein, but no exaggerated collateral supply. This was evidently a case of lymphatic stagnation without venous obstruction and is included for purposes of comparison.

It is evident from this study that the deep circulation is capable of considerable alteration without completely losing its function. In none of the 12 cases of deep venous thrombosis studied by this method has there been a complete and lasting blockage of the deep veins. There was found in each case an adequate deep circulation from both the clinical and roentgenographic point of view. The Perthes test was uniformly negative in this group.

The question of increase in size of the affected limb is a puzzling one. It may be held that the increase in the area of the venous bed due to extensive collateral vascularization is a factor. Those patients who exhibited superficial varicosities were treated by injection, with definite improvement. They felt better, and the limb became somewhat smaller. According to the previously accepted rule, these cases of "deep venous block" should not have been injected.

Practically, venography in cases of hypertrophy of the lower extremity serves a definite purpose. It differentiates between the lymphatic and venous types of enlargement. This is important because proper therapy will relieve lymphostasis. There is no treatment for hypertrophy due to venous thrombosis. These cases feel well and complain only of the cosmetic appearance. The use of supportive bandages is usually unnecessary except for excessive swelling.

This study, while preliminary in nature, indicates the need for a changed viewpoint on the problem of unilateral enlargement, especially in cases following deep venous thrombosis. Investigators should be warned of the existence of mixed types in properly evaluating their results.

SUMMARY

1. Unilateral enlargement of the lower extremity in cases of varicose veins has been studied by a contrast injection technique.

2. Enlargement due to incompetent communicating veins of the leg can be demonstrated with this technique.

3. This method helps to differentiate between hypertrophy due to lymphatic block, and that following deep venous thrombosis.

4. So-called "deep venous block" is relative, not absolute. A sufficiently adequate deep venous circulation has been demonstrated in all of the cases studied.

5. The deep venous system shows a marked ability to repair itself by collateral growth.

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Vol. 42, No. 5

ROENTGEN DIAGNOSIS OF RENAL INFECTION*

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THE preliminary roentgenogram, retrograde pyelography, and urography make possible the integration of function and pathology of the urinary tract. We have undertaken to correlate bacteriology and roentgenology in a series of our own cases to determine the advantages and limitations of these methods in the detection and classification of renal infection, and to learn whether or not bacteria cause characteristic roentgen pathologic processes or appearances. Roentgen diagnoses were not influenced by a previous knowledge of the bacteriology of the urinary tract, history, physical, or cystoscopic findings. Interpretations were made absolutely from roentgen evidence.

The kidney from which urine was cultured is considered the unit. It is necessary to consider negative and pure cultures since pathology in the presence of mixed bacteria could not be attributed to any particular organism. There should be a general consistency of interpretation of the pyelograms depending on whether the cultures were negative or positive, and on the probable pathogenicity of bacteria as determined by accumulated clinical experience. Clinical diagnoses are considered briefly. The procedure has definite limitations, but we believe it is worth while.

Tuberculosis and perinephritic infections are not considered.

Material. This consists of 476 consecutive urological patients referred to the Department of Roentgenology over approximately a twelve month period. Interpretations, with few exceptions, were made by me. A culture of the urine from one or both kidneys was made on 63 of the patients, or 13.2 per cent. Positive cultures were obtained in 74.6 per cent of the 63 patients. There were 40 females and 23 males, and cultures were positive in 70 per cent of the females and 82.6 per cent of the males. The maximum percentage of positive cultures was obtained after thirty years of age and the percentage was greater in men than women. One or both kidneys were pyelographed in 54 cases, and a total of 91 kidneys were pyelographed.

Negative Cultures. Twenty-two pyelograms were made on a total of 16 patients with bilateral negative cultures, and a negative roentgen interpretation was made in 81.8 per cent, while 18.2 per cent were considered infected. The clinician considered the latter to have a definite clinical pyelitis or pyelonephritis and there was complete accord between the roentgenologist and the clinician as to the kidney involved. This result is used as a standard of interpretation.

Bacillus coli. The relative incidence of *Bacillus coli* cultures was 38.3 per cent. Fifty per cent were bilateral pure cultures, 27.8 per cent unilateral pure cultures with the opposite urine sterile, 16.7 per cent a pure culture of *Bacillus coli* in one kidney and a different organism in the other, and 5.5 per cent had a mixed culture of *Bacillus coli* and *Bacillus pyocyaneus*. The incidence of positive cultures in females was practically three times that in the males.

Eighteen kidneys from which a pure culture of *Bacillus coli* was obtained were pyelographed and renal infection was diagnosed in 50 per cent. The others were considered normal. The roentgen interpretation and the urologists' final diagnoses agreed in 77.7 per cent, but there was complete agreement clinically, roentgenologically and bacteriologically in only 50 per cent.

Bacillus alcaligenes fecalis. The relative incidence of *Bacillus alcaligenes* was 34 per cent. The incidence of this organism is unusually high but it is accepted as recorded by the clinical laboratory. A negative roentgen diagnosis was made in 93.3

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per cent. The one case interpreted positively had a small parenchymal abscess, and the diagnosis was "probable tuberculosis." The urine was negative for tubercle bacilli and the clinical diagnosis was pyelonephritis. The exact type of infection remained questionable since surgery was not performed. A final clinical diagnosis of pyelitis or pyelonephritis was made in 33.3 per cent.

Staphylococcus epidermidis. The relative incidence of *Staphylococcus epidermidis* was 12.8 per cent. A negative roentgen interpretation was made in 80 per cent, while 20 per cent (one case) was considered to have a pyelitis by the roentgenologist and the clinician.

Gram-Negative Bacilli. This group was not classified further. The relative incidence was 14.9 per cent. A roentgen diagnosis of renal infection was made in 50 per cent while the remainder were considered normal. There was complete clinical and roentgenological agreement in all except one case which was considered negative by the clinician, but the roentgen diagnosis was supported by a positive culture.

Gram-Positive Cocci. There were 2 patients who had a unilateral culture of a gram-positive coccus. One case was interpreted as calculous hydronephrosis with infection and the other as a pyelitis. The clinical diagnoses were ureteral calculus and renal tuberculosis respectively. The urine was negative for tubercle bacilli; surgery was not performed.

Gram-Positive Bacilli. One patient had a unilateral culture of a gram-positive bacillus which was probably a saprophyte. The roentgen diagnosis was a normal kidney and the clinical diagnosis was prostatic hypertrophy and hydroureter.

Factors Influencing Roentgen Diagnosis of Renal Infections. The diagnosis of renal infection must be based on definite criteria. These are established by the response of tissue to injury by the offending organism. The various methods of investigation contribute to the evidence permitting a diagnosis. The roentgen signs of renal infection are well known and will not be reviewed. A few important factors to be recalled in approaching diagnosis will be considered.

The Primary Roentgenogram. The preliminary roentgenogram is not of much positive value in the diagnosis of uncomplicated urinary tract infection. A kidney enlarged by edema and hyperemia may be demonstrated, but the variable size of kidneys in the same individual detracts from the value of this sign. Gradual enlargement during the acute stage with continued decrease in size accompanying clinical improvement may be noted if successive roentgenograms are made during the course of the disease. We have observed this process continue to small inflammatory contracted kidneys ending in renal insufficiency. This demonstration of the pathological process differentiates this type from the small kidney of Bright's disease. Occasionally one will observe a lack of distinctness of the psoas shadow on the affected side, and if there is much pain, there may be a slight scoliosis away from the affected side. Occasionally one can detect some irregularity of the renal cortex in suppurative pyelonephritis. These signs indicate the kidney involved but by themselves do not permit a positive diagnosis.

Urography. The urogram makes it possible to observe the abnormal physiological reactions to disease as well as to observe the pathology. Urography very often excels the retrograde pyelogram since it permits an integration of clinical symptoms, abnormal physiologic reactions and pathologic processes with considerable accuracy. Due attention must be given to the mechanics of the entire urinary tract, and most information is obtained when there is no physical interference by the various methods of compression techniques. We do not favor compression technique and believe that, if it is used, it should be reserved until the degree and type of disturbed function are determined. Routine roentgenograms at specified intervals are not of as much value as a series made according to the indications of the individual case. The nature of the problem is nearly always indicated on the five minute urogram, and

each successive roentgenogram should be made at time intervals which are most likely to clarify the problem at hand. The roentgenologist should strictly supervise the technique of urography rather than place the responsibility on a technician.

The influence of renal and pelvic edema; spasm of the renal pelvis, ureter, and bladder; exudate adhering to the renal epithelium and detritus in the kidney pelvis; contractility and irritability; influence of variable degrees and types of obstruction, all must be considered in the interpretation of the urogram. The renal pelvis and calyces persistently distended are more apt to be diseased than the ones which contract rhythmically and are demonstrated infrequently. It is also necessary to remember that occasionally there is more rapid excretion by an acutely infected than by a normal kidney. Sometimes it is not possible to differentiate between an active infection and the residual fibrosis from an old infection. The shape of the bladder as it gradually fills often indicates the side involved and possible degree of activity because the coincident ureteritis, spasm, and inflammation about the ureterovesical orifice cause asymmetrical distention and abnormal shapes. The normal elliptical or oval shape of the bladder often becomes rounded or perpendicular and contracted on the pathologic side, not from organic change but from disturbed function, which seems to be a reflex phenomenon. These abnormal physiologic and organic changes have been more important, in our experience, in the diagnosis of infection than the degree of function as indicated by the concentration or elimination of the dye.

Retrograde Pyelography. Pyelographic interpretation is also influenced by the factors discussed above. It is necessary to realize that incipient pyelitis may not be shown by the retrograde pyelogram because the edema, exudate, detritus, or increased pressure, may be of insufficient amount and degree to be demonstrated. One must guard against making a diagnosis of "insufficient filling of the renal pelvis with the pyelographic medium" for it is entirely possible that much of an apparent lack of filling is due to edema of, and débris or retention in the kidney pelvis. It is doubtful if pyelitis exists long without some degree of simple pyelonephritis but we have not felt that we could make a differential diagnosis from the roentgen evidence. A diagnosis of a suppurative pyelonephritis can be made when a break in the pelvic mucosa is demonstrated or areas of parenchymal necrosis are outlined by the medium flowing into necrotic channels or abscess cavities. It should be recalled that an advanced suppurative pyelonephritis may be present and not be shown by pyelography, and occasionally areas of parenchymal necrosis can be demonstrated in the presence of a normal appearing pelvis because fistulas leading from pelvis to the abscess may be so small that lines of communication are obscured and only the filled abscess is shown. This observation has been confirmed by surgery.

Discussion. In this type of study it is necessary to consider bacteriology as well as the relative pathogenicity of organisms as established by accumulated experience. Comparable results should be obtained on cases with sterile urine and on those whose urine harbors relatively non-virulent and non-pathogenic bacteria, and also only a reasonable number of positive interpretations should be made in the presence of bacteria of known high virulence and pathogenicity. Is there such agreement? We believe the following table tends to show that there is a reasonable degree of constancy of interpretation and indicates that roentgenology when considered alone contributes a great deal to the diagnosis of renal infection.

Pyelograms	Bacteriology	Roentgenology	
		Positive per cent	Negative per cent
22	Negative	18.2	81.2
18	*B. coli*	50	50
15	*B. alcaligenes*	6.4	93.6
5	*Staph. epidermidis*	20	80
6	Gram-negative bacilli	50	50
2	Gram-positive cocci	100	0
1	Gram-positive bacilli	0	100

The roentgen diagnoses are confirmed to a high percentage by the bacteriological studies, the probable incidence of clinical disease in the presence of bacteria, and the pathogenicity and the virulence of the organisms for the urinary tract. We were not able to establish criteria which would permit us to advance with assurance an opinion as to the causative organisms. There was some discrepancy between the clinical diagnoses, and the bacteriological and roentgenological evidence, sometimes a clinical diagnosis of infection being made when both bacteriology and roentgenology were negative. We suggest several reasons for this discrepancy, and also when such a discrepancy does exist suggest and advise that a final diagnosis of renal infection be made cautiously.

A clinical infection may be present and not be demonstrated by pyelography or urography for the reasons previously considered. A single negative urine culture does not necessarily mean that the kidney is sterile. A positive culture does not necessarily mean that a clinical disease is present. Persistent negative cultures do not exclude renal infection. Also, the presence or absence of pus or blood in the urine, the clinical symptoms and the physical signs have not been considered critically in this study, all of which would be necessary in order to correlate accurately the clinical with the laboratory and roentgen diagnoses. This clinical study could be made accurately by the attending urologist only, and by considering his own series of cases, and such a study would be most difficult.

This analysis emphasizes the necessity for unprejudiced cooperation between the laboratory, the clinician, and the roentgenologist, and the advisability of avoiding jealous misunderstanding about the relative merits of the various diagnostic procedures. The greatest good to the patient is obtained by an intelligent disinterested evaluation of each method of investigation, and an interested application of all facts to treatment.

CONCLUSIONS

1. A negative roentgenogram does not exclude pyelitis.

2. A differential diagnosis between pyelitis and non-suppurative pyelonephritis cannot be made roentgenologically.

3. A diagnosis of suppurative pyelonephritis can often be made from the pyelogram or urogram but a negative roentgenogram does not exclude suppurative pyelonephritis.

4. A suppurative pyelonephritis from direct extension of a pelvic infection is demonstrated occasionally though the renal pelvis appears normal.

5. Bacteria do not produce pathognomonic roentgen characteristics or pathologic processes that permit classifications as to the etiology from roentgen evidence alone.

6. Roentgen diagnoses checked by cultures of the urine and probable pathogenicity of bacteria are definitely complementary and a clinical diagnosis of renal infection should be made cautiously when these are negative, but such a clinical diagnosis is not disqualified by negative cultures or roentgen findings.

7. Renal infections can be efficiently studied either by the retrograde pyelogram or urography but the diagnosis of infection must be based chiefly on organic pathology.

8. The roentgen examination is a most valuable procedure in the investigation of renal infections and all evidence obtained by it must be most seriously considered and appraised before the final clinical diagnosis is made.

We wish to express our appreciation to the Urological Staff of Methodist Hospital, Indianapolis, Indiana, for access to clinical records and to Dr. Bernard Kalayjian, Roper Hospital, Charleston, South Carolina, for his help in assembling the material.

Vol. 42, No. 5

EFFECT OF SMALL STONES ON RENAL FUNCTION*

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ALTHOUGH it was a generally accepted fact that obstruction from any cause produced changes in the ureter and kidney, the extent, duration, and recession of such changes were not thoroughly studied until intravenous urography became a routine procedure. In 1935, Wilcox† wrote his observations on the function of the kidneys in calculous obstruction, basing them on the results of pyelograms made following the introduction of intravenous preparations used for this purpose, and furthered the work by experiments on rabbits and the reaction of the kidneys during and after mechanical obstruction of the ureters.

Our own observations on the elimination of intravenous dyes in the presence of small ureteral calculi have been limited to clinical material and as a further demonstration of the changes (repression) taking place in the affected side, the following case reports are given in brief.

CASE 1 (No. 36607). C. L. S., male, admitted on June 8, 1936, complaining of pain in the left lumbar region radiating to the scrotum. Very severe and with intermittent attacks. Onset forty-eight hours before.

Upon admission patient had a temperature of 101.8° F., pulse 90, and respirations 20. He was normal upon physical examination except for tenderness over the left kidney region and just above the flare of the ileum anteriorly on this side. His urine was normal except for a heavy trace of albumin and a few granular casts. Red blood count 4,400,000; white blood count 11,200 with 60 per cent polymorphonuclear leukocytes.

The morning after admittance the patient was cystoscoped and found to have an obstruction to the passage of a catheter about 2 cm. above the bladder on the left. Manipulation at this time produced a small fragment of stone from the left orifice but the obstruction persisted. An intravenous pyelogram was done twenty-four hours later and reported as follows:

Right kidney is normal in size, shape, and position, and functions normally throughout the examination. The right pelvis and ureter are entirely normal. The left kidney does not function well but the series of roentgenograms shows a gradual increase in the density of the

FIG. 1. Case 1. Right pelvis filled. Left kidney shows clearly in outline designating filling of secreting portions of kidney. Taken five minutes after intravenous pyelographic medium was injected.

kidney indicating the increase in concentration of the dye but not enough passing into the drainage portion to visualize the pelvis and ureter. In the plane of the ureter about 2 cm. above the bladder, there is a very small shadow which we believe to be a small stone.

Seventy-two hours later another intravenous series was made and reported as follows: Right kidney, pelvis and ureter normal in all respects. The left kidney still shows some retardation of function with definite concentration of dye in the kidney substance before outline of the pel-

* From the Urological Service of the Kentucky Baptist Hospital, Louisville, Ky.

† Wilcox, L. F. Kidney function in acute calculous obstruction of the ureter. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, 34, 596–605.

FIG. 2. Case 1. Showing right pelvis emptied and left beginning to fill. Hydronephrosis mild on the left. Taken twenty minutes after intravenous pyelographic medium was injected.

vis can be seen. In the twenty-minute film, however, the pelvis can be fairly well outlined and in thirty-five minutes is quite definite. It shows moderate dilatation but with some blunting of the calyces and the shadow previously seen is now absent (Figs. 1, 2 and 3).

The clinical course of this patient is of interest from other standpoints also. He ran the the typical course of acute pyelitis. His temperature ranged from 101.8° F. upon admission to 104.4° F. upon the fourth day and reached normal for the first time upon the seventh day, and remained practically so until his discharge. His urine became loaded with pus cells the second day, and contained gradually decreasing amounts until discharge when it contained only an occasional one. His red count remained practically stationary but his white blood cell count rose as high as 19,000 and at this time with 90 per cent polymorphonuclear leukocytes. Several times at the height of his temperature he had chilly sensations but at no time had an actual chill. He was discharged on his twenty-first hospital day as cured.

CASE II (No. 36407). A. L. Z., male, admitted on May 20, 1936, complaining of pain in left side radiating to the scrotum, occurring intermittently, with the first attack forty-eight hours before.

Upon admission his temperature was 100° F., pulse 90, and respirations 20. Physical examination was negative except for slight tenderness over the left kidney area and along the left ureter. The urine was negative except for one plus albumin. Red blood count was 4,420,000; white blood count was 19,950 with 78 per cent polymorphonuclear leukocytes.

The day following admission the patient was cystoscoped under gas anesthesia and all attempts to pass a catheter up the left ureter failed because of an obstruction just above the orifice.

The second day after admission an intravenous examination was made and reported as follows:

The kidneys are normal in size, shape and position. There is prompt and adequate function on both sides and no evidence of organic changes. The right kidney fills and empties

FIG. 3. Case 1. Showing right side still empty. Left side shows dilatation of pelvis more clearly. Taken thirty-five minutes after injection of pyelographic medium.

promptly but on the left there is a retardation in emptying of the pelvis and ureter both of which are somewhat dilated with some tortuosity of the ureter and kinking, and just above the intramural portion there is a small dense shadow evidently a small stone (Fig. 4).

The hospital course of this patient was very smooth. At no time did his temperature go above 100° F. and was normal on the fourth hospital day. He was discharged as improved on the fifth hospital day and although the small stone was not recovered he has had no further attacks, and his urine has remained normal now almost a year after.

Case III (No. 35825). L. A. P., male, admitted on March 27, 1936, complaining of pain over both kidney areas radiating to the groin, most severe on right side.

The onset was four days before with pain accompanied by vomiting. He went to the hospital immediately where on the morning following admission a cystoscopic examination was done and catheters passed on both sides but with some obstruction just above the bladder on the right. Roentgen examination at that time showed a small shadow on either side in the course of the ureters which was diagnosed as possible bilateral ureteral stones. He left the hospital the same day, but continued to have recurrent attacks of pain with frequency which, on one occasion, was accompanied by hematuria. He returned to the hospital the fourth day after discharge.

Upon re-admission his temperature was 101.2° F., pulse 76, and respirations 20. Physical examination was negative except for tympanites and tenderness over both kidney areas and along the course of the ureters. His urine showed two plus albumin, and many red and white blood cells were seen microscopically. Red blood count 4,500,000; white blood count 14,600 with 82 per cent polymorphonuclear leukocytes.

He was cystoscoped at once under gas anesthesia but all attempts to pass catheters up on the right side failed because of an obstruction just above the orifice. A plain roentgenogram taken after cystoscopy was reported as a small shadow low down in the course of the right ureter. Following the cystoscopic examination the patient had no further pain on the left but pain continued intermittently on the right. His temperature became irregular, reaching 104° F. on several occasions accompanied by chilly

Fig. 4. Case II. Showing dilatation of the left pelvis with kinking of the left ureter. Stone shown at bladder level, not fully obstructing. Taken ten minutes after administration of dye.

sensations and nausea. On the third hospital day his temperature began to fall gradually and the pain became less severe and occurred not so often. His urine continued to contain many pus cells and a few red blood cells and, although no stone was recovered, apparently free drainage had been established. On the fifth hospital day and after his temperature had reached normal, an intravenous study was made and reported as follows:

The left kidney is slightly larger than normal, the pelvis and ureter being slightly dilated and with some tortuosity in the lower segment. The right kidney is quite large and although there is an increase in the density of the shadow indicating a concentration of dye in the secreting portion, there is no outline of the pelvis and ureter on this side until forty-five minutes after injection, and then only a suggestion rather than a true shadow. The shadow seen in the plain film was not shown (Figs. 5 and 6).

The clinical course in this case clearly indicates an acute pyelitis following stones and, as demonstrated by the intravenous studies, there was a definite and rather prolonged repression

Fig. 5. Case III. Showing good pelvic outline on the left side but only filling of the secreting portion of the right kidney. Taken five minutes after administration of the dye.

Fig. 6. Case III. Showing left side emptied to large extent. Right side shows filling of secreting portions of kidney but no pelvic outline. Taken forty-five minutes after administration of dye.

of secretion on the right side. The evidence was not entirely conclusive, however, because the stone was not recovered but there has been no recurrence of pain or pyuria during the year past since his hospital stay, and his appearance is that of a thoroughly healthy individual.

Case IV. (No. 38899). H. V. T., male, admitted on January 6, 1937, complaining of pain in the left lumbar region radiating to the left scrotum. Onset forty-eight hours before with

Fig. 7. Case IV. Showing right pelvis and ureter but only filling of the secreting portions of the left kidney. Taken five minutes after administration of dye.

nausea and vomiting, frequency and hematuria. Upon admission temperature was 100° F., pulse 86, and respirations 20. Physical examination showed tenderness over the left kidney and anteriorly over the left lower quadrant. Urine showed microscopic blood but was otherwise negative. Red blood count 4,350,000; white blood count 14,800 with 80 per cent polymorphonuclear leukocytes. On the third

hospital day he was cystoscoped under gas anesthesia, but a catheter could not be passed on the left side because of an obstruction just above the bladder. No roentgenogram was taken at this time because of nausea and vomiting. Intravenous urography done in the afternoon of his third hospital day was reported as follows:

The right kidney functions well and empties satisfactorily. The left kidney is very large,

Fig. 8. Case iv. Showing right kidney pelvis completely emptied and definite increase in the kidney shadow on the left. Taken one hour after administration of dye.

smooth in nature and shows a gradual increase in density in the secreting portion but without evidence of enough dye to outline the pelvis or ureter. No stone can be demonstrated (Figs. 7 and 8).

For three days after cystoscopic examination the patient improved. His pain lessened and temperature gradually returned to normal,

Fig. 9. Case iv. Showing return of function to left kidney after relief of obstruction. Taken five minutes after administration of dye. Second series.

Fig. 10. Case v. Showing right pelvis well filled. Left showing more marked filling of secreting portion and dilatation of the pelvis and ureter. A shadow low down on the left. Taken five minutes after administration of dye.

FIG. 11. Case v. Showing both pelves drained but the left kidney still well outlined, evidence of retardation (repression) in function. Taken twenty minutes after administration of dye.

and his urine cleared. Upon the sixth hospital day the intravenous pyelograms were repeated and reported as follows:

Both kidneys are functioning well and the greater amount of dye is excreted in half an hour. There is no evidence of dilatation or infection. No stone is demonstrated (Fig. 9).

CASE V (No. 37986). R. C. W., male, admitted on October 9, 1936, complaining of pain in left lumbar region radiating to the testicle. Onset about three hours before with pain, nausea, and weakness. Urine appeared highly colored. Physical examination showed a normal individual with some pain and tenderness in left lower quadrant. Temperature, pulse, and respirations were normal. Urine normal except for 10 to 15 red blood cells per high power field. Blood count normal. A plain roentgenogram taken shortly after admission showed a small shadow just above the sacrum on the left. An intravenous pyelogram was reported as follows:

The right side appears to be normal in all respects. The secretion on the left is retarded somewhat, there is an increase in density of the secreting portion and some dilatation of the pelvis and ureter (Figs. 10 and 11).

During the following two days the patient improved. He reported several times that he felt the stone moving. Two days after the intravenous series a plain film showed the shadow to be much lower, apparently at the ureterovesical orifice (Fig. 12).

DISCUSSION

The most usual and consistent change occurring in these cases was a definite retardation of function with a rapid return to normal as soon as the obstruction had been removed. The exact cause of these changes is not clear but it would appear that they cannot be entirely explained on the basis of increased pressure alone because a residual dilatation of the pelvis or ureter was not consistently found. When dilatation did occur (Case 11) the question arose as to whether there had not been previous attacks of pyelitis on the affected

FIG. 12. Case v. Showing fine stone now within bladder area. Plain plate taken two days after intravenous series.

side. Subjectively pain was present in all cases, as would be expected, and this together with a marked increase in the strength and number of ureteral contractions probably acts in the nature of a nervous reflex and produces the repression of function noted, which as a protective mechanism reduces the chances for further pelvic dilatation.

Pyelitis occurred in two of these cases but with the onset of free drainage rapidly receded without any special treatment. In both of these cystoscopy and manipulation had been done so that infection was not a too surprising sequence.

SUMMARY

Five cases of acute calculous obstruction of the ureter are presented.

In such obstruction a delay in drainage occurs from the secretory portion of the kidney into the pelvis.

An actual retardation of function, as shown by comparison of the normal and diseased kidney, probably also occurs.

Both of these changes are reversible within a short time after the relief of obstruction.

A residual dilatation of the pelvis and ureter is not usual.

RENAL TUBERCULOSIS

PATHOGENESIS AND ROENTGEN FINDINGS*

By HENRY K. TAYLOR, M.D.
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IN PRESENTING this subject I wish to give my impressions of the pathogenesis and localization of tuberculous infection in the kidney. I shall attempt to clarify statements in the literature which to me have been ambiguous. From my point of view renal tuberculosis should not occur as a complication of pulmonary tuberculosis, as we ordinarily use and understand these terms. The terms *pulmonary tuberculosis* and *complication* require explanation. When the statement is made that an individual has *pulmonary tuberculosis* that statement refers to a lesion which is a secondary or superinfection, and not to the primary tuberculous infection. Even the incipient tuberculous lesion, which is a small and early lesion, is also a secondary lesion or superinfection. This lesion in the lung, the superinfection, *is not responsible for the development of a complicating renal tuberculosis*. A renal tuberculosis can and often does coexist with a secondary pulmonary tuberculosis, but is not a complication of it. What do we usually mean by the term complication? A *complication* is a secondary disease due to another existing and active disease in the body. We do not view two separate diseases in one individual as complications of each other. An ingrowing toe nail and a pulmonary neoplasm are not complications of each other. But, a metastatic lesion is a secondary disease due to the presence of an existing disease, and is a complication.

The term *renal tuberculosis*, within the scope of this paper, includes an infection of the kidney by the tubercle bacillus producing a destructive lesion, which is referred to as organ tuberculosis. This does not include the pathologist's designation *acute tuberculous lesion* in which tubercles are found as part of a miliary tuberculosis. This latter lesion is not recognizable clinically and requires no comment.

Renal tuberculosis occurs as a complication, secondary to tuberculosis elsewhere in the body, usually pulmonary,[3,6,7,11,15] is a common statement in urologic literature. The presence of tubercle bacilli in the kidney is indicative of an extrarenal source of entrance with delivery of the organisms to the kidney. In this sense only is it secondary. As I view it, the deposition of organisms in the kidney is part and parcel of the primary tuberculous infection, and should not be considered as a complication; especially since the deposition of organisms during the primary phase of the infection is not necessarily followed by disease.

Some hold that the primary infection starts as a pulmonary lesion with involvement of the regional lymph nodes. If the primary infection is severe enough a bacillemia ensues. There is a discharge of tubercle bacilli from the involved regional lymph nodes, with subsequent fixation of the tubercle bacilli in any organ. There are others who hold that the primary infection starts as a bacillemia, irrespective of the mode of entrance of the tubercle bacilli into the body. The organisms are fixed in one or more of the organs after the development of allergy. The above contentions in the pathogenesis of tuberculosis are probably true. The fixation of the tubercle bacilli in the kidney will in all probability be the anlage for the future development of a renal tuberculosis. In those cases where no bacillemia occurs as part of the primary infection, there will be no deposition of tubercle bacilli in the kidney. Because of the infrequency with which renal tuberculosis occurs with reinfections or super-

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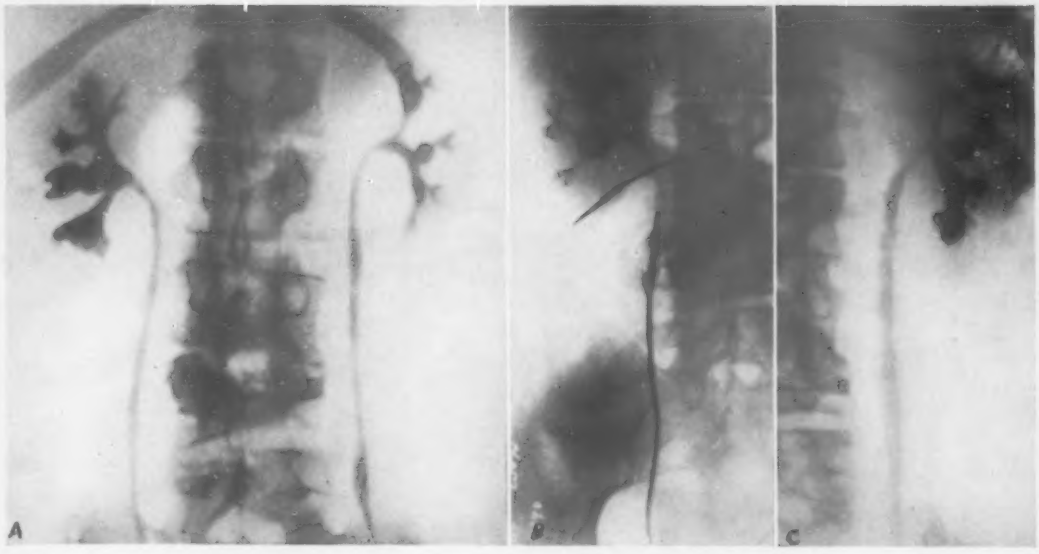

Fig. 1. J. P., male, white, aged nineteen. *A*, slight alteration in the architecture of the calyx in the upper pole of the right kidney. The left urinary tract shows no abnormal findings. *B*, one year later. Progression of the lesion with marked alteration in the architecture of the renal sinus, right side. *C*, one month later. Extensive involvement of the left kidney and ureter.

infections elsewhere in the body, I cannot convince myself that renal tuberculosis occurs as a complication of pulmonary tuberculosis. It is not my intention to be dogmatic and make the absolute statement that renal tuberculosis *cannot* occur as a complication. If it does occur the probability is that it is exceedingly rare.

In a recent article by Miller,[9] under a discussion of endogenous phthisis, he indicates the pathologic conception of the primary complex as described by Parrot, Kuss and Ghon, and attributes to Ranke . . . "The post primary dissemination from the lymphatic pole *through the lymph and blood stream, with numerous deposits in various organs** but especially in the apical and subapical zones of the lungs, and from these foci the development when the conditions are favorable of active organic phthisis. From this point *the disease spreads no longer by lymph and blood stream** but by the air passages, the so-called method of bronchogenic spread. . . ." He admits the hematogenous dissemination during the primary phase. Once pulmonary phthisis is established as a reinfection the disease no longer spreads by means of the blood or lymph stream. There is a hematogenous dissemination of the tubercle bacilli during the phase of the primary infection. When pulmonary tuberculosis is present, as a reinfection or superinfection, dissemination no longer takes place by means of the blood or lymph stream to the urinary tract or other organs.

In a recent article Bandler and Milbert[2] also admit a hematogenous dissemination; in discussing the etiology of renal tuberculosis, they make the following statement: "An embolic phenomenon represents the most common mechanism of dissemination, irrespective of whether the renal exacerbation occurs immediately or after months or years smoldering to a final flare up."

In Sea View Hospital, an institution for the tuberculous, tuberculosis of the urinary tract was found in 3.8 per cent of 1,121 consecutive autopsies, where all deaths were due to tuberculosis.

Bandler and Milbert quoting Caulk[5] of Barnes Hospital, St. Louis: . . . "From 1916–1921, the average number of tuber-

* Italics are my own, not in the original article.

culosis patients, in whom renal tuberculosis was subsequently disclosed and treated, was twenty cases a year, representing a ratio of 1 to 300. From 1921–1929, these figures dropped to sixteen cases a year, or 1 in 400. From 1930–1934, the ratio had fallen to 1 in 450."

In a survey made by Reisner[12] to determine the relationship between extrapulmonary and pulmonary tuberculosis, he found that 49.3 per cent of his cases had no pulmonary lesion. His figures also revealed that one-third of the cases with urinary tuberculosis were free from pulmonary lesions.

In 1936, Sutherland and Braasch[14] published their findings in a review of 1,314 cases of renal tuberculosis. Their findings are quite interesting. Of the 1,314 cases 911 were investigated for pulmonary tuberculosis. Of the 911, 631 cases, or 69.3 per cent, showed no evidence of pulmonary tuberculosis, and 280, or 30.7 per cent, revealed some evidence of tuberculosis and, to quote them, "in the majority being latent." It must be assumed that less than 50 per cent of the 280 showed evidences of a pulmonary lesion which could be considered as active. Of the entire group of 1,314 cases with renal tuberculosis, coexisting bone lesions were present in only 83. Despite these figures the authors claim "the consensus of opinion is that renal tuberculosis is never a primary condition but is always secondary to involvement of the lungs, peri-bronchial or retro-peritoneal lymph nodes or bone."

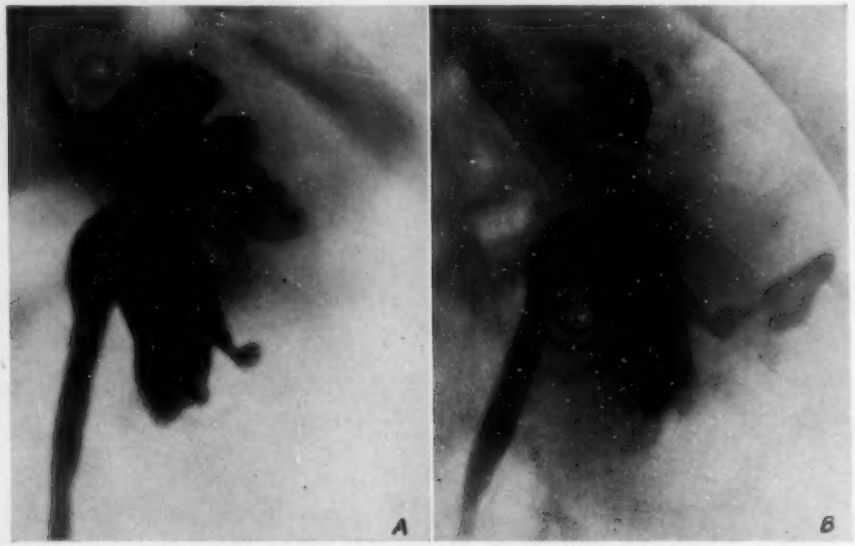

Fig. 2. J. C., male, white, aged forty-one. *A*, the alteration in the architecture of the renal sinus indicates extensive involvement of the kidney. *B*, fifteen months later. The alteration in the architecture of the renal sinus is more pronounced with stenosis and obliteration of part of the renal sinus.

Salleras and von der Becke[13] found renal tuberculosis in 16 per cent of 1,724 patients with urologic symptoms.

The above statistical findings do not favor renal tuberculosis occurring as a complication of a tuberculous lesion elsewhere in the body, usually pulmonary, for (1) not all cases show a pulmonary or even an extrapulmonary lesion (excluding the healed primary), and (2) the low incidence found in deaths due to tuberculosis. The incidence of renal tuberculosis in the tuberculous should be considerably higher, if it occurred as a complication. The low incidence of renal tuberculosis can be accounted for by accepting the contention that the tubercle bacilli are fixed in the

kidney during the phase of the primary infection. At some later date, for whatever reasons, the tubercle bacilli become virulent and produce a lesion in the kidney which is recognized as renal tuberculosis.

Myers[10] quoted by Miller: "We know that once the primary complex has been allowed to develop, as manifested by a positive tuberculin reaction, there is no treatment of any avail; that is, the condition is beyond recall. Immunity does not develop sufficient to *destroy the tubercle bacilli.** No treatment that we know, such as long periods of strict bed rest or even collapse therapy, *destroys the tubercle bacilli in the lesions of the primary complex.*"* In other words once the primary complex has been established, viable organisms are present, even though they do not produce disease.

Again quoting Miller: ". . . A positive reaction to tuberculin represents a state of allergy and indicates a previous tuberculous infection, but of course not necessarily the presence of active disease. In fact, in the large majority of reactors the lesions which may still exist are entirely latent and inactive."

Hematogenous dissemination of the tubercle bacilli in secondary or superinfections is probably rare. The frequency of complicating tuberculous lesions is low when the tubercle bacilli must be transported by the blood stream, and high when there is a direct, or tubular contact. There is a high incidence of recovery of tubercle bacilli from the gastric contents in individuals ill with caseous pneumonic type tuberculous pulmonary lesions. In other words, laryngeal and intestinal tuberculosis occur with considerably greater frequency as a concomitant complication of pulmonary tuberculosis than does either genitourinary or osseous tuberculosis. Associated with this is also the fact that positive blood cultures in pulmonary tuberculosis are exceedingly rare. This latter statement is made admitting the possibility of a lack of technical knowledge. Added to this is the absence of hematogenous disseminations following the severely traumatizing surgical procedures in tuberculous individuals, such as thoracoplasties, nephrectomies, and bone fusion operations.

The kidney is composed of a cortical and medullary portion. The medullary portion contains a number of pyramids, the apices of which project into the renal sinus, into the secondary or minor calyces. The cortical portion of the kidney is the peripheral portion as well as that portion of the renal substance situated between the pyramids. It is accepted that organisms are brought to the kidney by means of the blood stream. The localization of tubercle bacilli can occur in many places: at the apex of the pyramid, base of the pyramid, cortical substance between the pyramids and in the periphery. These areas are mentioned because the blood supply breaks up into capillaries in these areas and is therefore likely to be the place for organisms to be arrested.

Fig. 3. E. C., female, white, aged eighteen months. The kidneys show cortical ulcerations. No communication with the renal sinus.

Wildbolz and Ekehorn[16] believe the renal papilla is the site of election for the primary localization of the tubercle bacillus. They believe that the bacilli localize here because

* Italics are my own, not in the original article.

of the decreased velocity of the blood at this point. Medlar[8] states that the first lesion may localize either in the cortex, the medulla or in both. In his series of cases the lesions were cortical in 75 per cent, medullary in 11 per cent, and were present in both places in 13 per cent. Cabot and Crabtree,[4] and others, claim that the earliest localization of the tubercle bacillus occurs at the base of the pyramid. It is claimed by some that the tubercle bacilli are filtered out into the urine and localize in the region of the narrowed portion of the collecting tubule distal to the glomerulus in the cortex.

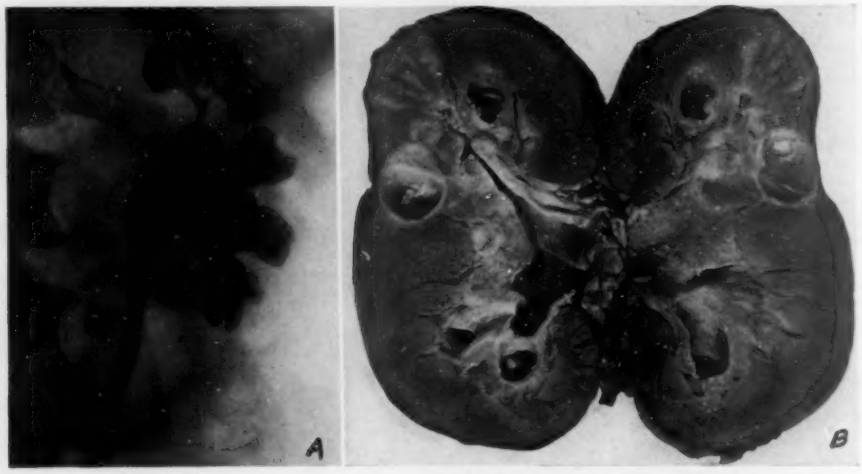

Fig. 4. F. W., male, white. *A*, deformity of the architecture of the renal sinus in the upper pole indicating a moderately extensive lesion. *B*, pathological specimen reveals an ulcerated lesion affecting the upper portion of the renal sinus. There is also present an ulcerated lesion in the cortex which has no communication with the renal sinus.

Apparently, the tubercle bacilli can localize anywhere in the kidney. Insofar as the roentgen examination offers the only graphic findings to indicate an alteration in the morphological appearance of the renal sinus, an essential criterion in the diagnosis of renal tuberculosis, it becomes apparent that the so-called early lesion which can be recognized is one which shows the least or smallest alteration to the architecture of the renal sinus. This finding may be a very early lesion with little involvement of the kidney, or, it may be a far advanced lesion which originated in the cortex, at a distance from the renal papilla, and progressed to the state where the renal sinus now is also affected. The lesion starts where the tubercle bacilli are localized and that may be in the renal papilla, pyramid, base of the pyramid, cortex or cortical substance between pyramids. The localization of the tubercle bacilli is of importance for the site is the determining factor in whether the lesion will be recognized early or late.

To recapitulate, a small lesion does not necessarily mean an early lesion. A large lesion may only show roentgen evidences similar to a small lesion, or a large cortical lesion may show no roentgen evidences at all.

The roentgen findings in renal tuberculosis vary, depending upon where the lesion starts. The renal lesions are recognized by the alterations in the architecture of the renal sinus. When the lesion starts at the renal papilla it is recognized early, before considerable damage has occurred to the kidney. The affected calyx shows slight variations from the normal; it may be slightly dilated, blunted, irregular, or in-

distinct. As the lesion progresses, these changes become more pronounced and the calyx loses its normal contour. The concavity to the calyx is lost. The distal portion becomes wider and usually presents an irregular convex periphery. It becomes dilated and enlarged. This may occur at any calyx, but is found most often in the upper pole of the kidney. With progression of the lesion adjacent calyces, as well as calyces, detached irregular areas of contrast medium, isolated areas of necrosis, dilatation, narrowing and almost complete obliteration of the renal pelvis.

When the tubercle bacilli are localized at the base of the pyramid or in the cortex, and subsequently develop a lesion, there can be no early recognition of the lesion by present means, except possibly with planigraphy. This lesion must progress sufficiently, destroy tissue, until it reaches one or more portions of the renal sinus before it can be recognized. As long as the destructive lesion does not encroach upon the renal sinus there are no evidences of a lesion on urographic examination. When a lesion of this type, which may be fairly extensive, begins to encroach upon one portion of the renal sinus, it presents the same urographic findings as are observed in those cases where the lesion starts at the renal papilla, the real early case. Here you have an advanced lesion presenting urographic findings which are identical with a small and early lesion. From the roentgen findings, it is impossible to designate which case is early and which is advanced, when the deformity of the renal sinus is limited to a calyx. The roentgenographic evidence is not indicative of the size or the extent of the lesion.

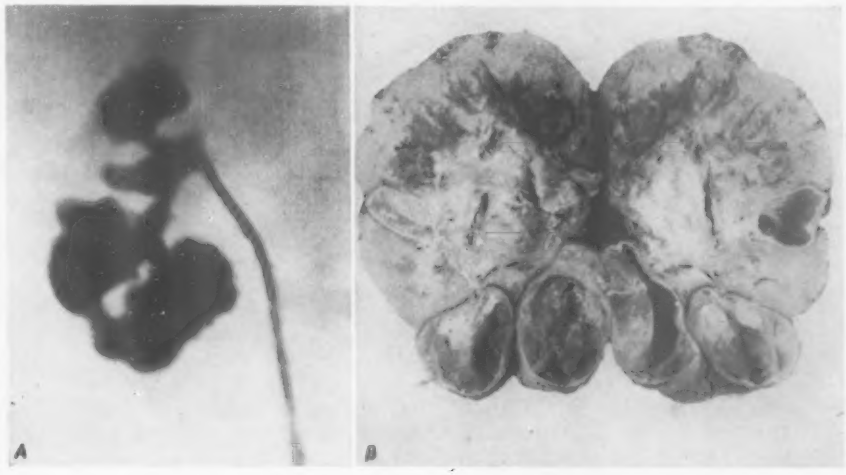

Fig. 5. L. C., male, white, aged twenty-nine. *A*, extensive alteration in the architecture of the renal sinus. *B*, pathological specimen.

the cortex, become involved. The destructive process involves a greater area, and the urographic examination reveals profound changes in the architecture of the renal sinus. There is fusion of the calyces with abscess formation. The lesion may so involve the substance of the kidney that a calyx or even a portion of the renal pelvis may become completely obliterated. Under such circumstances no contrast substance will enter the diseased area. In reality an abscess cavity is present with no communication to the renal sinus. Multiple lesions may progress simultaneously in the kidney, eventually producing multiple abscesses. As a rule, before extensive abscesses develop, the renal sinus may assume many bizarre shapes.

The advanced lesions present unusual appearances such as dilatations with markedly irregular contours, obliterations of

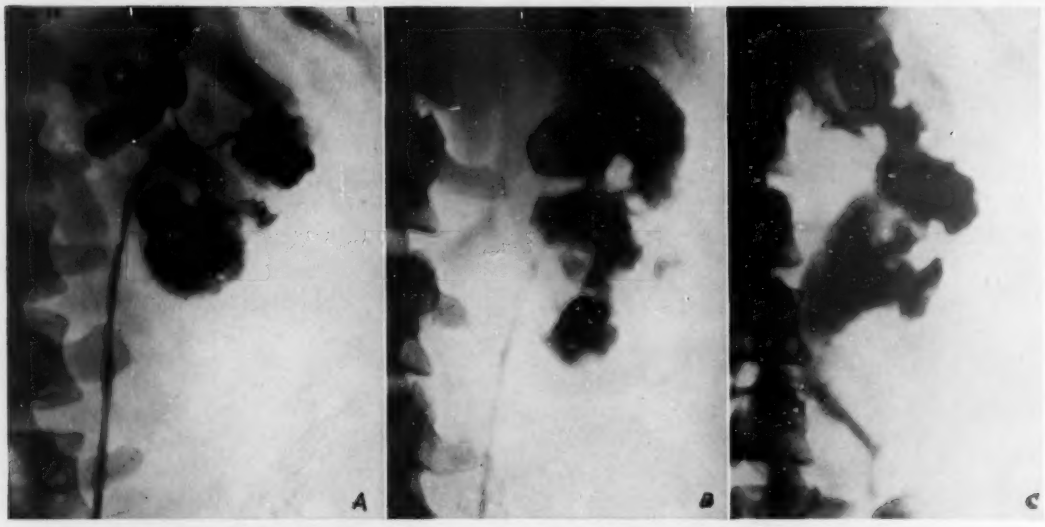

Fig. 6. I.F., male, white. *A*, *B*, *C*, marked deformities to the architecture of the renal sinuses indicating extensive lesions.

There are advanced cases of renal tuberculosis, where the lesions are cortical in location. These do not encroach upon or alter the architecture of the renal sinus. They present no urographic findings and cannot be detected. A negative pyelogram does not exclude a renal tuberculosis even though urography in many cases may be the only method by which one may arrive at a diagnosis.

According to Medlar[8] the localization of the tubercle bacilli most frequently occurs in the cortex (75 per cent). The early recognition of this lesion is impossible. Not until the lesion becomes sufficiently extensive to destroy one or more of the calyces will it be evidenced on the roentgen film. The lesions irrespective of where they start progress with a destruction of renal substance.

Destructive lesions of the kidney may be present with no communications with the renal sinus, and hence not demonstrable. It is not unusual to find at operation or necropsy multiple excavations in the kidney of which there were no evidences or indications in the roentgenogram.

The presence of small circular isolated calcific deposits,* either single or multiple, unilateral or bilateral, is usually considered as being tuberculous. The presence of these calcific deposits is no indication of disease in the urinary tract. If they are tuberculous in origin, they represent the end or healed phase of the primary infection. It is to be remembered that calcific deposits in the kidney may appear secondary to nontuberculous conditions.

* Calcific deposits of the kidney are not as frequently encountered in the East as in the Western States.

SUMMARY

The tubercle bacilli are deposited in the kidney or kidneys during the phase of the primary infection. The fixation of the tubercle bacilli in the kidney is part and parcel of the primary infection. A subsequent activation of the tubercle bacilli results in disease.

The localization of the tubercle bacilli may occur in any portion of the kidney.

The lesion in the kidney is recognized only when it deforms a portion of the renal sinus. Early recognition of the disease is possible only when localization of the tubercle bacillus occurs at the renal papilla. When the tubercle bacilli are localized elsewhere, the lesion cannot be recognized early. When there is no encroachment on the renal sinus, there is no roentgen evidence of disease. The roentgenographic

evidence is not indicative of the size or extent of the lesion.

The presence of small calcareous foci in the kidney may be due to the healed or end stage of a primary infection, and is no indication of disease in the urinary tract.

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DISCUSSION

Dr. B. H. Nichols, Cleveland, Ohio. Dr. Taylor has presented a very interesting paper on renal tuberculosis. I think all of us agree that infection takes place by way of the blood stream in the vast majority of instances. However, some noted urologists have warned against the procedure of catheterizing an apparently normal ureter and kidney in the presence of a tuberculous infection in the bladder because of the danger of direct transmissions of the infection to such a kidney or ureter.

I am not prepared to accept the theory of Dr. Taylor that the bacillus may remain dormant in the kidney for a long time before an active lesion becomes apparent. If we accept this as the method by which renal tuberculosis develops, then it is not necessary to remove a tuberculous kidney because of the danger that infection may spread to the noninfected kidney on the opposite side. We do know, however, that often, in the presence of renal tuberculosis, no so-called primary lesion can be demonstrated; on the other hand, about 15 per cent of the cases are accompanied by a frank pulmonary tuberculosis which we have not been able to rule out as a primary foci.

In the diagnosis of renal tuberculosis, we have relied on the pyelographic study to show what we considered to be rather characteristic changes which may be accompanied by single or multiple strictures of the ureter. When such a finding is present and is accompanied by acid-fast bacilli in the urine, the majority of all the operated cases of tuberculosis of the kidney show an ulcerated lesion which most often lies at the base of the pyramids at the reflection of the mucous membrane of the minor calyces. The characteristics of a tuberculous kidney as revealed by the pyelogram are a localized lesion with an irregular serrated edge, with no enlargement of the kidney, and the other portions of the kidney normal in appearance. The pelvis is not fragmented as in other types of infection unless there is a secondary infection or obstruction of the ureter. Calcific deposits which outline a portion of a calyx or the entire pelvis are characteristic. These findings, except for the calcific deposits, may be simulated by a squamous cell carcinoma of the kidney which is a rare condition and is often accompanied by an old kidney stone.

When there are acid-fast bacilli in the urine, we feel that a positive diagnosis can be made rather early. The presence of cortical infection, in our experience, has occurred much less frequently as a primary focus.

Dr. Taylor's observations are a valuable contribution to the subject of renal tuberculosis and I hope that they will stimulate further research to prove or disprove the method of infection and subsequent development of renal tuberculosis.

Dr. Taylor (closing). The question of the possibility of bacilli lying dormant and subsequently developing disease, which was raised by Dr. Nichols, is an old one. In favor of the above is that which is found in the literature.

Many investigators have recovered viable organisms from ossified and calcified Ghon tubercles as late as twenty years after the original localization of the lesion.

On the other hand, there are also workers who were unable to corroborate these findings. They were unable to recover viable organisms from Ghon tubercles. If that question is debatable, how can you account for your tuberculous lesions in the kidney without any focus of tuberculosis elsewhere?

Allowing that a pulmonary tuberculosis exists, in those cases where the transportation of the tubercle bacillus is by means of the blood stream to the kidney or osseous system, why is the frequency of that complicating lesion *low* as compared to the complicating lesion produced where there is a direct or tubular contact, as in the larynx and intestinal tract? Why is there such a great discrepancy? Perhaps my ideas are not entirely correct. I cannot correlate these two facts: (1) where there is a direct tubular or aerogenous contact, the frequency of the complication is high, and (2) where the blood stream has to be the disseminator, the frequency of the complication is low. I can account for it only by stating that tubercle bacilli have been deposited in the kidney or osseous system during the phase of the primary infection, and subsequently became active and developed a lesion.

In my experience I have never seen a secondary tuberculous lesion in the lung heal by calcification. If it does occur the frequency is rare. We do have evidence that the primary tuberculous infection in the lung does heal, leaving a calcific deposit. When secondary lesions heal, they either resolve completely or leave some evidences of fibrosis. By the same reasoning I believe that there are many nephritic infections in children which are probably part of the primary infection, and which heal leaving a calcific deposit in the kidney, quite similar to the healing process in the lung. However, that does not indicate the presence of an active renal tuberculosis. Entirely different from the former is a diseased kidney which has undergone considerable destruction with the deposition of calcium in caseous, necrotic, dead tissue. It is not to be misunderstood that a calcific deposit in the kidney is indicative of a healed primary infection. There are many causes for the deposition of calcium in the kidney, which have no relation to renal tuberculosis.

I wish to thank Dr. Nichols for his very kind discussion.

Vol. 42, No. 5

ROENTGENOLOGIC VISUALIZATION OF THE SOFT TISSUES IN PREGNANCY*†

By WILLIAM SNOW, M.D., *Director, Department of Radiology, Bronx and Harlem Hospitals, and* MEYER ROSENSOHN, M.D., *Obstetrician, Bronx Hospital, and Associate Obstetrician and Gynecologist, New York Hospital*
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IN THE past few years numerous attempts have been made to demonstrate the location of the placenta *in utero* with the aid of the roentgen rays. Some of these have been by the use of radiopaque media which have been injected either intravenously or by means of abdominal puncture through the wall of the uterus into the amniotic cavity. But such methods are not free from danger both to the mother and to the fetus.

In 1934 one of us[5] described a safe simple technique whereby, in a study of 60 cases, the outline of the placenta could be demonstrated in a majority of them. It was indicated that placenta previa might be discovered by this method.

In the following issue of the same journal Ude, Weum and Urner[7] reported on the roentgen diagnosis of placenta previa, based on 1 case but adding 2 more. Their work at first was without but later included sodium iodide injection into the bladder. Friedman and Macdonald[2] in 1935 reported 2 cases of roentgen diagnosis of placenta previa. They injected the urinary bladder with 25 cc. of a 5 per cent sodium iodide solution. A short time later Ude and Urner[8] using 40 cc. of a 12.5 per cent sodium iodide solution injected into the bladder again reported on the diagnosis of placenta previa. They claimed that air injections were less efficient and that the anteroposterior film was the better; the lateral film in their opinion is of very little value. They say, "It is on a careful analysis of the densities between the bladder margin and the skull of the fetus that we depend for a roentgen diagnosis of placenta previa."

The present report includes further studies on roentgen visualization of the soft parts of late pregnancy. The uterine wall, placenta, varying degrees of hydramnios, intra-uterine hemorrhage and even the amniotic sac have been demonstrated. The importance of a recognition of these structures is obvious. The technique is entirely devoid of danger and we have succeeded in making a positive diagnosis in late extra-uterine pregnancy as well as in some tumors causing dystocia.

Placenta, Uterine Wall, Amniotic Sac. It is important to recognize the normal roentgenographic findings for advanced pregnancy in order to be prepared for the abnormal. On the film, it can be seen that the fetus is surrounded by a pear-shaped soft shadow. This represents mainly the uterine wall, the placenta, and amniotic fluid.

The uterine wall can usually be seen toward the dorsal aspect of the fetus and is always evident when contrasted against the air-filled bladder on a lateral view. The cross diameter is usually 1.5 cm.

In the diagnosis of the site of the placenta it was found that this structure could be seen on routine roentgen examination of pregnancy in its late stages. The usual anteroposterior and lateral views were used but the latter is more helpful. The placenta is seen as a soft tissue shadow which occupies about one-third of the wall space of the uterine cavity (Figs. 1 and 2). It bulges in its middle where it measures about 7 cm. in diameter and tapers off at the periphery toward the uterine wall. The small parts of the fetus almost invariably face the placenta and by pressure cause digitations in its substance. The subcutaneous tissues of the fetus, since they consist largely of fat, are highly penetrable by the

* Read at the Thirty-ninth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 20–23, 1938.
† Material for this paper was selected from a group of more than 300 cases examined at the Harlem and Bronx Hospitals.

FIG. 1. Lateral view, normal pregnancy. Placenta seen as broad soft shadow on one side. Uterine wall seen as narrow soft shadow on other side. Subcutaneous fat of fetus (dark linear shadow between fetus and placenta) valuable clue for demarcating soft structures.

roentgen rays and as a result they leave a black line between the fetal parts and the placenta. For the elbow this may measure about 2 mm. and for the buttocks as much as 1 cm. Normal amounts of amniotic fluid do not cast a sufficient shadow to be recognizable. In doubtful cases it has been found desirable to take a right and a left lateral film to exclude the possibility of overshadowing of the placenta by the fetus in one or the other view.

Amniotic fluid in normal amount does not cause a sufficient shadow to be of any consequence. When excessive its shadow often hides that of the placenta. This will be considered again.

The amniotic sac has been seen only with abdominal pregnancy. This is probably because the heavier shadow of the uterine wall was absent. In the presence of a living fetus it measured between 1 and 2 mm. on edge (Figs. 3 and 4). Where the fetus had been dead for some time it measured up to 3 cm. across. In one case this thickening was undoubtedly due to infection.

The umbilical cord has not been demonstrated.

Cesarean Section. If there has been a previous cesarean section we believe it is highly important to determine whether the placenta has been implanted at the site of the scar. Dr. Charles S. B. Cassasa as a medical examiner for New York City in a personal communication states that he has seen several fatal cases where the uterus had ruptured at the site of the scar because of placental implantation in that area. In some cases the rupture had occurred during labor and in others even in the absence of labor. If the site of the placenta is known as well as its relation to the scar of a previous cesarean it may be a determining factor in deciding whether a mother may be permitted to deliver *per vaginam*, all other indications being favorable, or whether to operate again. Recently the importance of this was shown by Gerrard[3] who reported a case with Cullen's sign due to rupture of the cesarean section scar. He thought that the attachment of the placenta to the anterior wall of the uterus predisposed to scar rupture, as was pointed out some years ago

FIG. 2. Lateral view, normal placental and uterine shadow.

by another English gynecologist, St. Georg Wilson.

Placenta Previa. In cases suspected of placenta previa, we began by filling the bladder with a radiopaque substance but quickly changed to air injections. Our experience was the opposite of that of Ude and Urner; the radiopaque material frequently overshadowed the lower part of the uterus and caused confusion. When sodium iodide solution was used, it had to be drained because it frequently caused irritation of the bladder. On the other hand, the air injections caused no untoward symptoms. Under the usual precautions, 150 cc. of air is introduced, the catheter is removed and the patient sent to the Department of Roentgenology. Anteroposterior and lateral views are made as part of a pelvimetric study. If the placenta is in its usual location, it is found near the fundus.

Fig. 3. Abdominal pregnancy. Lateral view. Note fine white line over top of skull caused by amniotic sac in absence of uterine wall. Fetal parts cause digitations in placenta beneath. Shadows of properitoneal fat of mother fuse with those of fetal subcutaneous fat because uterine wall is not present.

Fig. 4. Abdominal pregnancy, lateral view, similar to Figure 3.

With central placenta previa a soft tissue shadow will be cast between the fetal skull and the urinary bladder. Filling the latter with air makes a marked contrast with the soft tissue shadows and overlapping of the two only serves to intensify the difference (Figs. 5, 6, 7 and 8). With the use of radiopaque material, the overlapping hides the shadow of the placenta. Frequently aerocystograms indicate that the urinary bladder has been displaced above the symphysis and to the right or left and only a narrow channel can be seen extending behind and below the symphysis in the lateral view. This usually indicates that the fetal head is engaged.

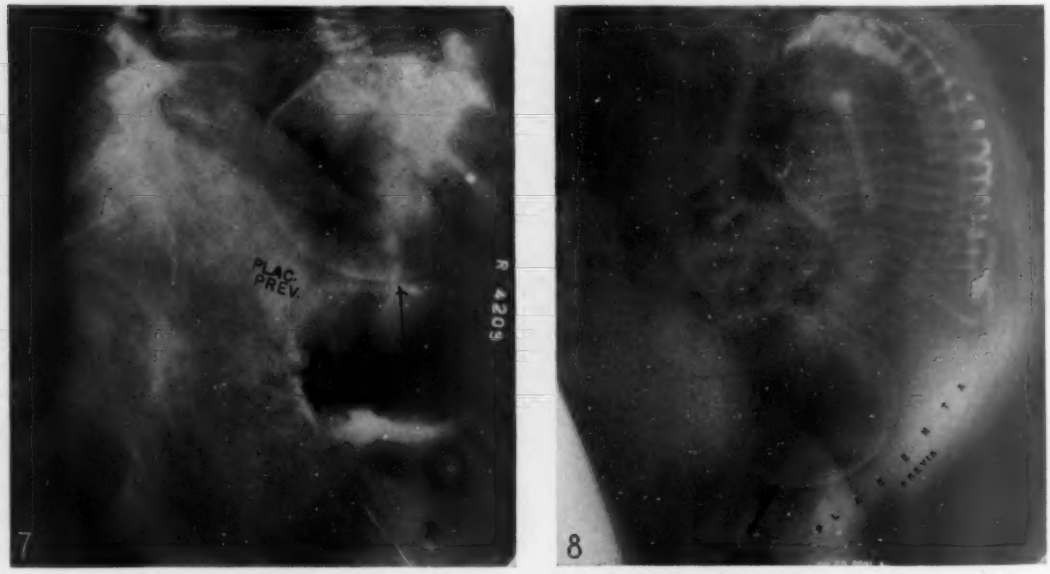
It has been our experience that central placenta previa and marginal placenta previa extending forward or laterally could be demonstrated by these studies, but, were the placenta to be located mainly on the posterior wall, it would not come between the fetal head and the bladder. However, the fact that the placenta would not be found in its usual site would be suggestive of placental implantation on the lower posterior wall of the uterus of the marginal previa type. We are now taking into con-

Figs. 5 and 6. Placenta previa on anteroposterior views. Air in bladder discloses placenta between it and vertex. Overlapping of air shadow does not hide the placenta.

sideration the presence of gas in the rectum as a contrast, to help further in locating the placenta. It has been found expedient in some cases to inject air *per rectum*.

The breech presentation in the presence of placenta previa may obscure the picture because the buttocks can cause marked compression of the placenta. In such a case we were able to confirm the clinical diagnosis of placenta previa because the placental shadow was nowhere to be seen.

Placental Apoplexy. In connection with premature separation of the placenta, in their original paper Snow and Powell[5] reported a case of placental apoplexy. This was characterized by a localized bulge of the uterine wall (Figs. 9, 10 and 11). Since then we have recognized several other cases on roentgen examination. In thin patients where the bulging is anterior it can be made out on palpation. However, where the bulge is posterior or the patient is



Figs. 7 and 8. Placenta previa. Lateral views. Indicates how far placenta extends posteriorly.

obese, palpation does not help, and roentgen examination is of distinct value in locating the bulge regardless of its position. It must be borne in mind that fibroids may give the same roentgen findings.

Polyhydramnios. With regard to the increase in the amniotic fluid, we have learned to recognize the existence as well as in some measure the degree on roentgen examination. The uterus as a whole is disproportionately enlarged in comparison to the size of the fetus. The large quantity of fluid casts a shadow which cannot always be differentiated from that of the placenta. There is the same soft shadow density and the same digitation in both, which is caused by the fetal small parts. However, since these geographic shadows surround the fetus on all sides, it is logical to assume the presence of hydramnios rather than an enormous placenta covering the entire uterine wall (Figs. 12 and 13). This diagnosis of polyhydramnios has been frequently made and corroborated. It is best seen in roentgen studies of intra-uterine monstrosities. A review of 30 cases of varying degrees of hydramnios showed that while twins were diagnosed clinically the roent-

Fig. 9. Placental apoplexy. Lateral view. Note bulge of uterine wall.

Fig. 10. Pregnancy with large fibroids showing bulge similar to placental apoplexy.

Fig. 11. Placental apoplexy resembling fibroids shown in Figure 10.

FIG. 12. Hydramnios. Soft shadow with digitations. Surrounds fetus and obscures shadow of placenta.

gen examination showed the existence of excessive fluid with but one fetus. It is important to repeat that the presence of hydramnios makes it difficult to recognize the placenta.

Extra-uterine Pregnancy. We have all seen on roentgen study early extra-uterine pregnancy. It is recognized by the presence of fetal parts lateral to the uterus. The latter can be seen even in the absence of pregnancy as was reported by Carty.[1] If the fetus continues to develop to full growth the clinical diagnosis becomes very difficult. Snow[6] recently reported 2 cases that were recognized on roentgen examination alone. The placental implantation was shown and even the amniotic sac. The uterine wall was missing over the fetus. The latter was disposed relatively high in the abdomen and beneath it could be visualized a large soft tissue shadow showing digitations. This was obviously the placenta. It is very likely that the reason the amniotic sac could be visualized as a thin-walled covering over the fetus was because of the absence of the heavier uterine wall (Figs. 3, 4, 14 and 15).

Since then we have recognized several such cases. Where the fetus was alive the roentgen findings were generally as described above. However, where the fetus had grown to full size and then had died *in situ* the picture was different. The fetus showed the usual signs of death from overlapping of the cranial sutures to a bundle of bones. The amniotic sac had become so thick that its shadow resembled that of uterine wall due to the infection that had taken place (Fig. 16). In one such case iodized oil had to be injected *per vaginam* into the uterine cavity in order to establish the diagnosis. It is interesting to note that Greenhill,[4] in a case report of extra-uterine pregnancy, states that the amniotic sac was thick and that the fetus was macerated.

There is one helpful point we would like to bring out which has developed in the course of our studies. In the films, the fundus of the female bladder, whether a radiopaque substance or air is used, shows a crescentic border, concave upward. The curve thus shown, be it a segment of a small or large circle, may give a clue to the

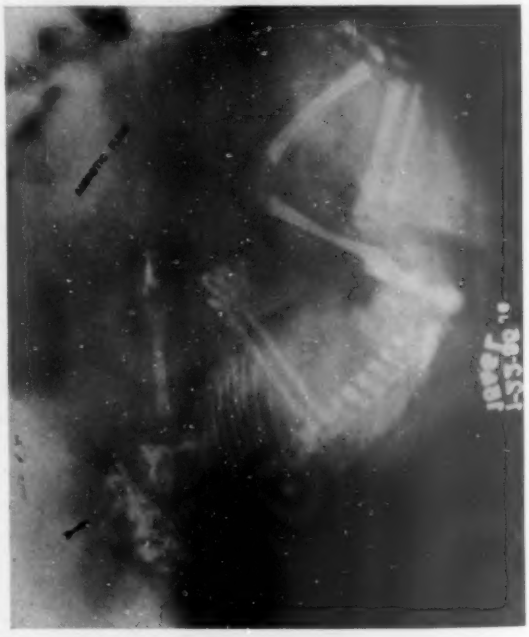


FIG. 13. Anencephaly with hydramnios similar to Figure 12.

overlying structure of the uterus which is compressing it. Thus a very large segment might suggest the existence of a placenta previa with a vertex above it, while a very small segment might indicate the presence of a small uterus and thus disclose a late extra-uterine pregnancy.

Another helpful point in recognizing the absence of the uterine wall over the fetus

Fig. 14. Abdominal pregnancy. Anteroposterior view. Fetus displaced upward. Uterine wall absent over fetus. Original film shows soft tissue shadow of placenta below fetus with digitations where it meets fetal parts.

is brought out by studying the relation of the soft tissue shadows of the abdominal wall and the fetal parts. A blackening of the film in the form of linear shadows can be seen between them when they are in close proximity. This is caused by the properitoneal fat of the mother and the subcutaneous fat of the fetus. In normal pregnancy the uterine wall should be interposed. With abdominal pregnancy the amniotic sac may be seen* (Fig. 15).

* We are indebted to Dr. H. J. Stander, Dr. Frederick Kassebohm, Dr. Charles Posner, Dr. Julius Kurzrok, and Dr. Irving Smiley for permitting us the use of their material in the study of the extra-uterine pregnancies in particular.

Fig. 15. Abdominal pregnancy. Amniotic sac can be seen outlined against maternal abdominal wall.

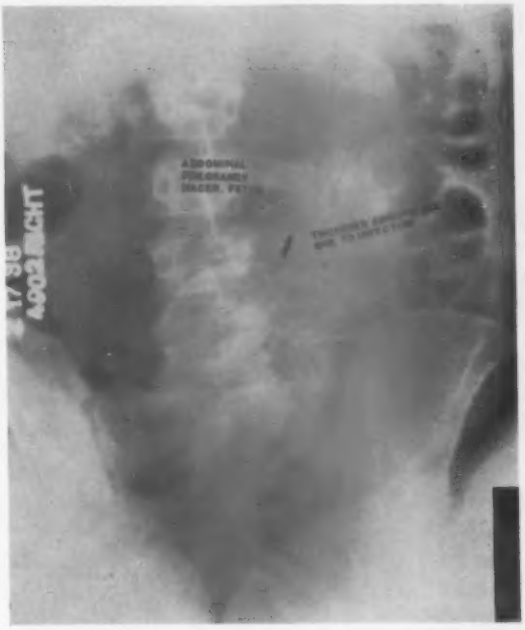


Fig. 16. Abdominal pregnancy. Fetus macerated. Because of secondary infection the amniotic sac became so thick that it resembled uterine wall. Key to diagnosis was that patient began to menstruate.

Fig. 17. Pregnancy with large fibroids showing calcium deposits.

Tumors. Some tumors in the lower uterine segment or in the pelvis causing dystocia lend themselves to roentgen diagnosis by the presence of calcific deposits in the case of fibroids or teeth or bone in dermoid cysts (Fig. 17). The soft tissue shadow produced by the tumor may also be visualized. The knowledge of the normal roentgen appearance of the soft tissues of pregnancy is therefore of value. The bladder aerogram is particularly helpful in disclosing such masses that are adjacent (Fig. 18).

Bleeding. Since bleeding may be a presenting sign in abnormal pregnancy we are presenting some of our roentgen experiences from this approach. It would seem highly desirable to make it a routine to use the roentgen ray under such circumstances.

A patient complained of blood-stained evacuations. Roentgen examination showed a normal location of the placenta. Delivery was later normal. Investigation proved that she had developed an eczema posterior to the vulva with bleeding skin fissures. It is conceivable that hemorrhoids, fissure *in ano*, cervical polyps or similar benign conditions could produce the same picture.

Patients with placenta previa first present signs of vaginal bleeding. Roentgen examination enabled us to differentiate between a placenta previa centralis and marginalis. In the first condition operation was imperative. In the second condition conservative measures could be resorted to and a vaginal delivery permitted.

With placental apoplexy there is often vaginal bleeding. The demonstration in the roentgenogram of the bulge of the uterus is very helpful additional evidence in establishing the correct diagnosis.

Some of our late extra-uterine cases came in with the history and signs of pregnancy but they had begun to menstruate again. In these the fetus was dead. Others came in with signs of severe concealed hemorrhage caused by separation of the placenta from its attachment. In all these cases the roentgen examination contributed materially in establishing the diagnosis of abdominal pregnancy.

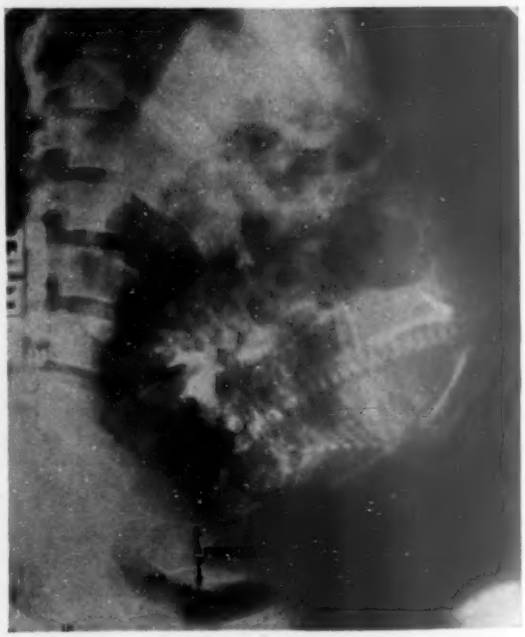


Fig. 18. Pregnancy. Aerogram reveals a fibroid of the lower uterine segment which resembles placenta previa.

SUMMARY

We have demonstrated by roentgen study the conditions enumerated below and briefly referred to their practical value:

1. The site of the placenta.
2. Placenta previa—central and partial.
3. Premature separation.
4. Polyhydramnios.
5. Extra-uterine pregnancy.
6. Some tumors causing dystocia.

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DISCUSSION

Dr. John R. Carty, New York City. With the increasing interest in soft tissue roentgenography, Drs. Snow and Rosensohn's paper is very timely. I have had the opportunity of going over their material and find it to be very interesting. As is the case with the exploration of the soft tissues elsewhere, there are numerous shadows which, when carefully studied and analyzed, give valuable information. Generally speaking, in the past they have been neglected. There is no question that the roentgenologist should know the soft tissue anatomy as well as he does the osseous and other structures. Success in this field comes as a result of diligent study of the normal, and constant attention to the technical factors. There is no branch of roentgen diagnosis where technique is more important than in the soft tissues.

The illumination with which soft tissue roentgenograms are viewed is of some importance. In all my cases, I like to use illumination of various colors, particularly green, red and blue, and often in this manner some soft tissue detail becomes apparent which otherwise might be lost. Also, I think it is of help to use a magnifying glass. Magnification methods depending upon projection of a certain portion of the film have not been successful, due probably to the relatively small difference in density of contiguous structures.

Dr. Snow says that it is important to recognize the normal roentgen findings in advanced pregnancy. In this he is quite correct. I should add that it is equally important to know the normal structures throughout the entire cycle of pregnancy. It is particularly important to recognize hydramnios so that the possibility of interpretive errors regarding the position of the placenta may be brought to mind.

The injection of air into the bladder is a harmless procedure and helps in the tissue differentiation. I agree with Dr. Snow that an opaque medium in the bladder will not infrequently hide detail. It does have a place, however, where tumor of the uterus is suspected as a possible factor in dystocia. The character of extrinsic pressure is better studied and possible involvement of bladder wall more readily detected. The localized bulge in the uterine wall which Dr. Snow mentions is an interesting finding in apoplexy of the placenta. Oblique films may be of help in demonstrating this.

In certain instances, as Dr. Snow has mentioned, the rectum may be filled with air after a cleansing enema. The mottling caused by gas and intestinal contents may be quite confusing.

Extra-uterine pregnancy is well described by Dr. Snow. It gives a fairly definite picture. The presence of tumors which may cause dystocia can often be suspected. The tumors arising from bone are generally obvious. Soft tissue tumors may be overlooked unless they contain calcium.

ROENTGENOLOGIC VISUALIZATION OF THE SOFT STRUCTURES OF PREGNANCY

EXPERIMENTAL EVIDENCE*

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ON THE roentgenogram of advanced pregnancy there can be seen a black delineation between the fetus and the placenta. Proof of the nature of the structure that causes this black shadow is herewith submitted. Incidental to this study, the roentgen picture of hydramnios was produced *in vitro* which was identical to that *in vivo*.

FIG. 1. Roentgenogram of stillbirth immersed in water. Water can be seen as a soft shadow which engulfs the fetus. This is identical with the roentgen picture of hydramnios *in vivo*. Between the fetus and the water shadows can be seen the linear black line of demarcation caused by fetal subcutaneous fat.

Snow and Powell[1] in their original article assumed that the black shadow was caused by the subcutaneous fat of the fetus. Ude, Urner and Robbins[3] in a later report on the roentgenological diagnosis of placenta previa recognized the valuable aid of the linear blackening that Snow and Powell described, but claimed that it was caused by vernix caseosa. It was therefore decided that further clarification of this question was justified not only from a scientific point of view, but also because it would focus the attention of clinicians on its practical importance.

A stillborn fetus was roentgenographed while it was in an aluminum container filled with water. Not only was the vernix removed from this specimen but large areas of superficial skin were also peeled away. Despite this, the same linear black shadows were produced on the film. It was

FIG. 2. Photograph of a longitudinal section of fetal lower extremity. Note thickness of subcutaneous fat.

* Presented before the Radiological Section of the New York State Medical Society, April 27, 1939.

thus evident that the picture could not be caused by vernix (Fig. 1).

Next, a longitudinal section of one of the lower extremities was made. This exposed to view the long bones surrounded by muscles, which in turn were surrounded by layers of fat, which in turn were covered by the integument (Fig. 2). A roentgen examination of this prepared specimen showed three degrees of density on the film (Fig. 3). There was the bony type which is obvious; surrounding this was a gray type which conformed to the muscles, and surrounding this was a black type which conformed to the subcutaneous fat.

To establish further proof a quantity of vernix caseosa was obtained and rolled into a ball about 1.5 cm. in diameter. This was placed next to the prepared longitudinal section of the lower extremity and both were simultaneously roentgenographed. The thickness of the ball of vernix caseosa was less than that of the muscle or subcutaneous fat. The density of this body was approximately that of muscle, and decidedly not that of fat as is shown on the film (Fig. 4).

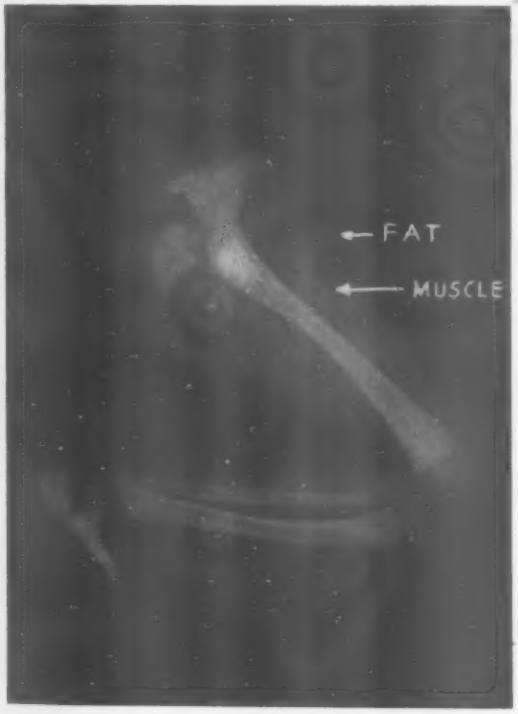

Fig. 3. Roentgenogram of specimen seen in Figure 2. Compare thickness of muscle and fat as seen in Figures 2 and 3. Vernix caseosa and superficial skin had been removed.

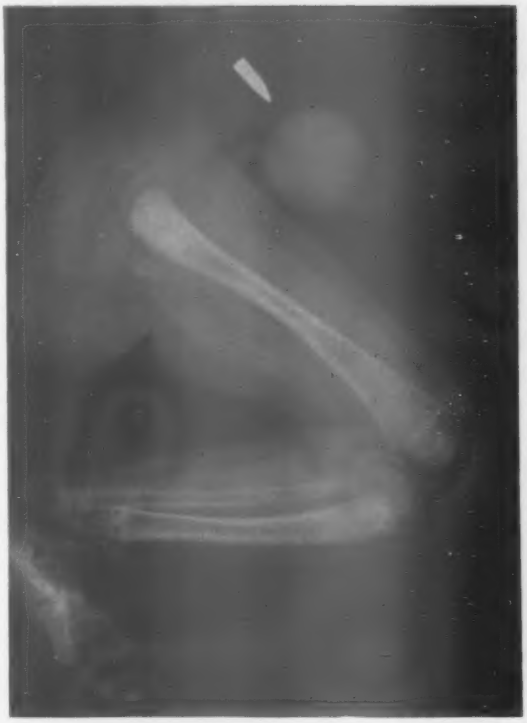

Fig. 4. Roentgenogram of specimen seen in Figure 2 with ball of vernix caseosa next to it. The density of the latter is more that of muscle than that of fat.

Figure 1 shows the linear black shadows on all sides of the fetus. In the region of the buttocks, back of the neck and thighs it is of broad diameter because the greatest deposits of subcutaneous fat are located at these sites. Surrounding the fetus can be seen the shadow of the water, the picture being identical with that of hydramnios *in vivo* on roentgen examination as described by Snow and Rosensohn.[2] It is extremely important to call attention to this because hydramnios is a serious hindrance in the recognition of the soft tissues of pregnancy on roentgen examination. It is particularly confusing because its appearance may be identical to that of the shadow of the placenta itself. In the presence of hydramnios characteristic geographic shad-

ows surround the fetus, whereas it is extremely unlikely that this would occur with the placenta alone.

SUMMARY

1. Attention is again called to the black line of demarcation seen between the fetus and placenta on roentgen examination.

2. Experimental proof is presented to show that the blackening of the film is evidence of the fetal subcutaneous fat.

3. Experimental proof is presented to show that vernix caseosa does not produce the shadow under consideration; and that instead vernix caseosa casts a shadow of the same degree as that caused by muscle.

4. The roentgen picture of hydramnios has been produced *in vitro* which was identical with the roentgen picture originally recognized *in vivo* by Snow and Rosensohn.

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Vol. 42, No. 5

SYMPUS MONOPUS

REPORT OF A CASE*

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A SYMPUS, sympodia or symmelia is a monstrosity in which the lower limbs are fused to a greater or lesser degree and more or less imperfectly developed, together with some defect in the bony pelvis.

The term monster or monstrosity (teratism) is properly applied to the fetal individual in its entirety, and to an extreme condition of physical malformation causing more or less interference with physiologic functions.

Normal growth is dependent upon the normal correlation of certain fixed physiologic laws, any deviation from which will result in abnormalities. This deviation is invariably the action of some extraneous force such as toxic, traumatic, mechanical, actinic or chemical, and manifests itself by a retardation of the rate of growth.

The fusion of the lower limbs is a condition that can occur only in the absence or reduction of the structures which normally intervene between them, i.e., the caudal end of the vertebral column and the cloaca. Narrowing of the tail end due to reduction of the vertebral column is probably due to a deficiency in the vascular supply. Such a narrowing causes approximation of the lower limb buds with resultant monstrosity.

Sympodia constitute about 1 per cent of all monstrosities. There are three types:

1. Sirenomelia or sympus apus, which is a mermaid-like creature in which the lower portion of the trunk tapers off into a point or stump without any pedal extremity and with only rudimentary ankle bones. This is the most common type.

2. Uromelia or sympus monopus, in which the ankle bones are present, the extremity terminating in a single fused foot. This is the rarest type.

3. Symmelia or sympus dipus, which presents two more or less distinct feet attached to the fused limbs.

CASE REPORT

Mrs. G., white, aged twenty-six, admitted to the Beth Israel Hospital on April 1, 1937.

Family History. Negative.

Previous History. Negative except for a myomectomy in 1934.

FIG. 1. Sympus monopus.

Obstetrical. Para 1, gravida 2. The previous pregnancy (before the myomectomy) was normal in all respects with a spontaneous delivery of a normal baby.

Menstrual History. The last period was August 7, 1936 (eight months ago).

* From the Department of Roentgenology of the Beth Israel Hospital, New York, Dr. I. Seth Hirsch, Director.

FIG. 2. Sympus monopus.

FIG. 3. Sympus monopus.

Physical Examination. There is a viable fetus in the breech presentation with a fetal heart rate of 160.

Subsequent Course. A stillbirth (monstrosity) weighing 5 pounds was delivered by a breech extraction, the entire labor lasting six hours.

The roentgen examination of the stillbirth visualizes a premature fetus of about eight months' size with no evidence of any air in either the lungs or in the gastrointestinal tract.

The skull is normal in all respects.

The cervical spine has seven segments all having their three primary centers of ossification present. There are bilateral cervical ribs arising from the seventh cervical.

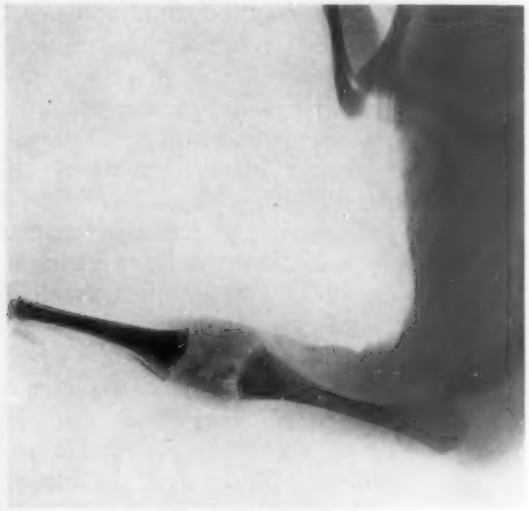

FIG. 4. Sympus monopus.

The dorsal spine contains twelve segments. There is incomplete ossification of the primary centers for the upper five segments with a hemivertebra at the fourth segment. The lower seven segments show normal ossification of the primary centers. There is a dextrorotatory curvature of the dorsal spine with the apex of the curvature at the fifth dorsal segment.

The ossification centers for the shoulder girdles, upper extremities and the thoracic cage are normal.

There are six lumbar segments all having normal ossification in their three primary centers.

The sacrum contains a few rudimentary and under-developed ossification centers.

There are no centers visualized for the coccyx.

The primary centers for the ilia and the pubic bones are normal. There are no primary centers visualized for the ischia.

The lower extremities are completely fused and are fixed at right angles in a forward direction to the long axis of the spine.

The proximal portion of the monopus, representing the fused thigh areas, contains one large long bone which shows evidence of having resulted from the fusion of the primary centers of each of the femora. This fused double femur is widened at the proximal end and shows marked flaring at the distal end. It is normal in length and almost twice the thickness of the normal femur. There are no capital epiphyses present. There are two epiphyses present at the distal end, each representing the normal distal femoral epiphysis.

The portion of the monopus representing the fused legs contains two normal tibiae with a normal single fibula placed between them. There are no epiphyseal centers present either at the proximal or at the distal ends of the leg portion.

The region just distal to the fused leg portion contains a single center of ossification which represents one of the calcanei.

At this point the distal portion of the monopus acutely folds upon itself in a dorsal direction for 180 degrees and comes to lie parallel to the distal end of the leg. This represents the fused feet and contains centers for two metatarsal and six phalangeal bones.

STENOSING ESOPHAGITIS ASSOCIATED WITH DUODENAL ULCER

REPORT OF A CASE

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THERE is reported in medical literature a certain number of peptic ulcers occurring at the same time in both the esophagus and duodenum. However, this condition is sufficiently uncommon to make the case we are reporting of interest and value.

Mr. G., white, aged forty-six, was referred to us on January 9, 1937. At that time he was complaining of weakness, dysphagia and loss of weight. He described the onset of his illness in this way. In 1934 he was disturbed by acute discomfort in his chest. The symptoms continued for some time and were finally traced

FIG. 1. Roentgenogram after gastroenterostomy.

to a duodenal ulcer. On September 17, 1935, the patient was admitted to a local hospital. At that time he had a duodenal ulcer, hematemesis and tarry stools. A laparotomy was performed a month later and a large duodenal ulcer was found in the first portion of the duodenum. A posterior gastroenterostomy was performed (Fig. 1).

On November 19, 1935, the patient was readmitted to the hospital. He was complaining of an inability to retain food. An esophagoscopy showed the lower half of the esophagus extensively involved in tumorous masses, soft to the touch, overladen with a fibrinous exudate. Some were ulcerated but with little or no bleeding. A month later a gastrostomy was performed. The report of the pathological laboratory on tissue removed for biopsy was: "Sections show diffuse necrosis, numerous hemorrhages, widespread granulation tissue. Many blood vessels are noted. There is no evidence whatever of neoplasm. In spite of this, however, I feel that this is a case of carcinoma. . . . " The patient was discharged a month later. He was receiving nourishment through a gastrostomy tube.

When the patient came to us a year later, he was still fed through the gastrostomy tube. At

FIG. 2. Roentgenogram showing esophageal stricture.

this time a roentgen examination showed an area of incomplete stenosis commencing just above the diaphragm and extending for a distance of 2 cm. (Fig. 2).

An esophagoscopy performed at the time showed a diaphragm across the lumen approximately 35 cm. from the upper teeth or just above the cardiac end of the esophagus. This diaphragm had a small perforation about 3 cm. in size, eccentrically located. There was moderate dilatation of the esophagus proximal to the diaphragm. The left lateral wall of the diaphragm was irregular after the manner of a scar, but the mucous membrane was relatively normal everywhere. A tiny bougie was passed through the esophagoscope and no further stricture was encountered. The stricture was then dilated until the largest bougie which could be passed through the esophagoscope was reached. Further dilatation was resorted to until a No. 43 Vinson-Plummer bougie could be passed.

A final examination at the beginning of the current year showed the patient to be in good condition with a gain of 28 pounds. His symptoms had entirely disappeared and the roentgen examination showed the removal of the stenotic area (Fig. 3).

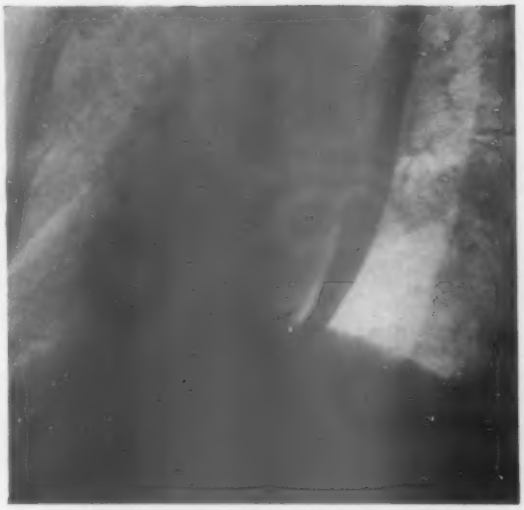

Fig. 3. Roentgenogram taken after esophageal dilation.

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THE RADIUM TREATMENT OF ANGIOMA IN CHILDREN*

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ANGIOMA or nevus is the common birthmark; it may cause such marked disfigurement that it influences the whole life of the individual, or may even in extreme cases produce a grave disability. The condition is always a mesothelial tumor and the cells which compose it are endothelial cells determined to the formation of blood and lymph vessels. It is a congenital abnormality resulting in excessive proliferation of these cells, described as hemangioblasts, and the degree of differentiation varies from the type where the cells form a solid tumor with little or no attempt at canalization to the formation of apparently normal blood or lymph vessels. The conception still found in many textbooks of a small system of vessels which have not become united to the vessels which carry the normal circulation is no longer accepted, nor is the explanation that the characteristic color is produced by the normal capillaries of a vascular stroma showing through the thin epidermis. The tissue is mesothelial and this stroma with the numerous capillaries is an intrinsic part of the tumor, so that the flat port wine stain of the capillary angioma is in fact a neoplasm although no tumor can be felt, and it is probable that the cirsoid aneurysm which appears to consist of fully formed vessels must also be included in the group, although it will not be discussed here.

From the point of view of treatment it is convenient to divide the angiomas into three types: (1) capillary; (2) compact; (3) cavernous, but it must be remembered that the tumor is usually classified from the predominating type, either two or three different arrangements of neoplastic tissue being present.

(1) *Capillary*. This is the port wine stain, a flat purplish discoloration often covering large areas. It consists of a rather loose stroma with enormous numbers of capillaries in which blood is circulating, and usually contains many partially formed vessels not yet canalized. The overlying epidermis tends to be very thin.

(2) *Compact*. This term usually refers to the rare solid angioma which consists of masses of hemangioblasts which have not differentiated to form vessels. These are sometimes found within the skull, and may be confused with meningioma. If they are in the subcutaneous tissues the characteristic discoloration is absent, and they may be mistaken for fibromas.

(3) *Cavernous*. All palpable tumors when combined with the characteristic discoloration of the hemangioma are usually referred to as cavernous. This is due to a misconception, the neoplasm consisting of a mixture of solid masses of hemangioblasts and the very vascular stroma already described. It is, however, convenient to use the term because it includes a group of tumors which show a specific reaction to radiation. Properly used the term "cavernous" infers the presence of large blood spaces within the tumor lined with endothelial cells and often communicating with numerous tortuous venous channels in which large phleboliths form. Such tumors if untreated may later become malignant, when they should be described as angiosarcoma, the term nevocarcinoma being reserved for malignant melanoma.

TREATMENT

Three main methods of treatment have been tried: (*a*) surgical excision; (*b*) cauterization; (*c*) irradiation.

(*a*) *Surgery*. When the lesion is small and there is plenty of tissue available to close

* Paper read at the Fourth Annual General Meeting, British Association of Radiologists, Belfast, May 13–14, 1938.

the incision without tension a small linear scar results, and a safe and permanent cure is obtained, but if the lesion is on the face or involves a large area on trunk or limbs the cosmetic result is not perfect. Keloid formation is a not uncommon sequel.

(*b*) *Cauterization.* Cauterization by CO_2 snow, electrolysis or diathermy may be used for very small lesions, electrolysis being the best method of treating "spider" nevi, but for any larger lesion the white scarring produced is unsightly.

(*c*) *Irradiation.* Irradiation either with gamma rays or filtered roentgen rays is the method of choice for all but capillary angiomas. For small lesions, beta radiation with unfiltered radium is sometimes advocated, and larger lesions are treated by fitting the beta plaques to different areas, but this method has the same disadvantage as CO_2 snow in that it leaves a white scar much more obvious than that left by gamma radiation. Filtered roentgen radiation at ordinary deep therapy levels produces the same effect as gamma radiation, but in treating young children it is difficult to keep them still and the greater depth dose is a disadvantage if an epiphysis comes into the field of radiation because of the possible interference with the growth of the bone.

GAMMA-RAY TREATMENT IN MANCHESTER RADIUM INSTITUTE

The object of this paper is to stress the fact that irradiation is a safe, certain method of curing these tumors, not a second resort to be attempted after CO_2 snow and other minor procedures have failed. It is justifiable to attempt the gamma-ray treatment of any angioma; there is no known satisfactory method of treating capillary types, the doses given do no harm, and if no response is obtained the attempt is abandoned. If there is any thickness of tumor tissue, this will be reduced and the discoloration will improve. Some indication is obtained by noticing the degree of blanching on pressure; if the capillaries empty easily, some soft vascular neoplastic tissue is present. The compact type responds well, and the so-called "cavernous," really mixed, may completely disappear. The true cavernous angioma also does well, and blood spaces may be obliterated but the tortuous vessels usually remain although with a much decreased blood content.

The best time to treat is during infancy, from three months to two years. It is probable that a good many of these tumors will disappear spontaneously about the fifth year, but this is a long time to wait with an unsightly tumor when the process of cicatrization can so easily be hastened without risk of permanent damage. The dose is modified to some slight extent according to age, and must be kept low enough to avoid any but very slight reactions. Although it is preferable to treat early, treatment is not contraindicated at any age, but as a rule angiomas persisting into adult life are capillary or else they are very large tumors, the radiosensitive nature of which has not been recognized. Marked improvement may follow irradiation even in the rare but interesting "hemangiomatosis," where there are multiple tumors involving large areas including the brain, but as a rule confined to one side of the body, not crossing the midline.

Our method of giving gamma radiation to these young children is to use radon; the emanation is sealed into silver seeds which are destroyed when the dose prescribed has been given. These silver radon seeds are applied on a mould built up from elastoplast or elastoplast felt, the method of making the mould being that described by Johnstone.* The distribution of the seeds follows the rules of the radium dosage system, the usual arrangement being the ideal circle which obtains homogeneous irradiation by making the ratio of the diameter of the treating circle to the radium skin distance as just under 3:1. The dose is calculated from graphs which give for the area treated the milligram-hours required. The mother is told to remove and burn the entire mould at a fixed hour when

* Johnstone, A. S. Adhesive applicator for radium therapy. *Brit. J. Radiol.*, 1935, *8*, 298–305.

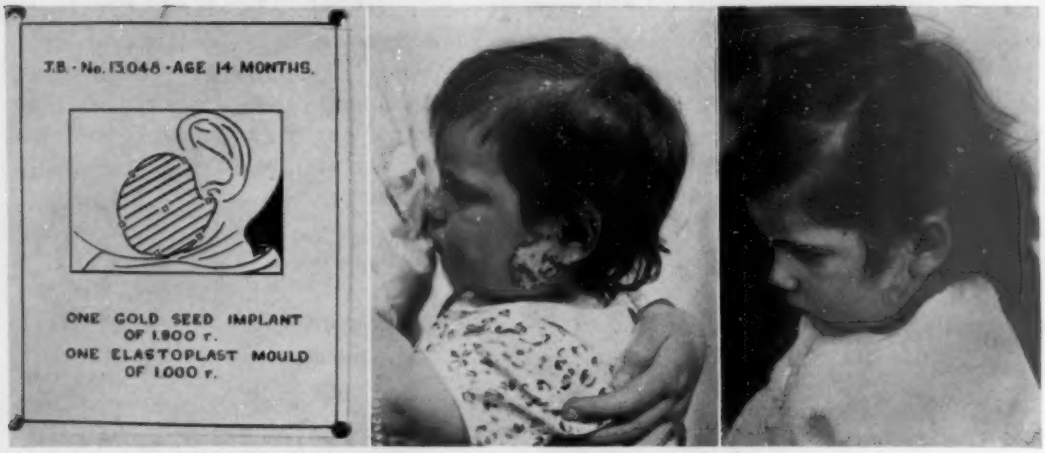

FIG. 1. Hemangioma of cheek before and after treatment, with diagram showing method of treatment. Note scarring due to CO_2 snow persisting when discoloration is almost invisible.

the dose calculated and prescribed has been delivered. The dosage rate is adjusted so that this takes five or six days.

If radon is not available, radium needles can be stitched to the elastoplast, and the baby brought back to hospital to have the elastoplast mould removed, thus allowing out-patient treatment with only slight risk of loss of radium.

In certain situations—near the eye, on the lip, or on the nostril—or if the tumor is very bulky, elastoplast moulds are not satisfactory because of the irregular surface and the difficulty of getting the plaster to adhere. Such lesions are best implanted with seeds containing radon filtered with 0.5 mm. of gold. The seeds are very small and can be left permanently in the tissues without producing obvious changes.

Two plans may be followed in implanting these seeds: (1) The seeds are arranged according to the dosage rules in circles or rectangles, and the dose is calculated at a distance of 0.5 cm. from the plane formed by the multiple sources. Unless the lesion is small, a center spot or an inner circle is needed, or if a rectangle is used cross bars, and as the large number of seeds is not very practical, larger tumors are implanted with removable radium needles. If seeds are not available, very small needles with small radium contents make excellent implants,

FIG. 2. Hemangioma of cheek and ear before and after treatment, with diagram of method. No previous treatment.

Fig. 3. Hemangioma of scalp before and after treatment, with diagram of method. Note normal growth of hair.

but it becomes necessary to keep the baby in hospital during treatment. (2) A single radon seed of comparatively high content is

Table I

(A) *Elastoplast Mould*
  (a) With radon seeds—5–6 days (out-patient)
  (b) With radium needles—in short time
  (c) With radium needles stitched to felt—5–6 days (out-patient)
(B) *Implant*
  (a) With radon seeds not removed
    (i) planar calculation
    (ii) point source
  (b) With radium needles

implanted at the center of the tumor, and the dose is calculated for a sphere of tissue irradiated from a point source. This method is useful for bulky lesions such as the compact angiomas found in the substance of the cheek. In such cases a slight degree of central scarring may be an advantage. These methods are summarized in Table I.

DOSAGE

The amount of radiation necessary to secure complete disappearance of the angioma varies greatly, and the only safe rule is that no individual treatment should deliver a dose high enough to produce at any time any obvious reaction of normal tissue. The mother when reporting should always be asked if the skin became red or irritable, and even a slight reaction should be regarded as an indication that the dose

Fig. 4. Compact angioma of orbit before and after treatment, with diagram of method.

should be lower at the next application. As a result of considerable experience, our dose for treatment with elastoplast moulds has been fixed at 1,500 r over four days, or 1,000 r over two days, repeated at two-month intervals. Two or at the most three such applications are usually enough, but if after waiting a year the tumor still needs treatment, the course can safely be repeated. The interval must never be less than two months. Occasionally a small outlying portion of the angioma remains which can be treated separately. One or two gold seeds are implanted in the center of the persistent area, thus localizing the radiation and avoiding a further dose to the previously irradiated tissues.

Sometimes a combined implant and surface application is planned, the implant dealing with the deep part of the tumor and the mould with the superficial discoloration. There is no absolute rule about the dose delivered, but 1,500 r is safe for either.

If implant only is planned from the beginning, it is possible to give rather higher individual doses to avoid numerous retreatments. For very young children, 2,000 r, and for older children, 3,000 r from plane implants, or 1,000 r at 2 cm. from a point source usually produces complete disappearance with one treatment. Slightly higher doses can be given on trunk and limbs where the cosmetic result is less important. Improvement sometimes continues for some time after an implant, and retreatment should not be undertaken too soon—an interval of six months is practical.

RESULTS OF TREATMENT

The number of cases treated at the Manchester Radium Institute from 1933 to 1936, inclusive, is 150, and as a rule the children only attend for about a year after the lesion is considered to be cured. It has therefore not been possible to see them all personally, and the notes and photographs in the history sheets have had to be accepted as adequate. The claims put forward for the treatment by radium may seem to be too sweeping when it is remembered that in some cases where the history is annotated "Well" some scarring was present. It is, however, true that in all these cases the angioma has completely disappeared, and the scars are often the result of attempts to treat with CO_2 snow before sending the baby for radiotherapy, or to the thin skin over the lesion accentuating the slight degree of atrophy following irradiation. In some cases, the slight scar stands out because of lack of pigment when the complexion is dark, or the baby is sunburnt. The results and methods of treating the cases in which good results were obtained are given in Tables II and III.

TABLE II

RESULT OF TREATMENT OF ANGIOMA
HOLT RADIUM INSTITUTE—1933–1936

Type of Angioma	Total Treated	Well	Improved	Not Improved
Capillary	16	0	8	8
Compact or cavernous	134	129	5	0
Totals	150	129	13	8

TABLE III

METHODS OF TREATMENT OF 129 CASES ANNOTATED WELL IN TABLE II

Type of Treatment	*Number Well*
Elastoplast mould	93
Stent mould	2
Implant and mould combined	5
Implant alone	29
Total	129

The treatment of angioma by radium is thus seen to be effective, and when properly controlled is without danger. The essentials are repeated low dose at correct intervals; this we suggest to be 1,500 r every two months, although other arrangements will be equally effective. If dosage is carefully calculated, and treatment is not continued indefinitely when it is obvious that a tumor of unusual resistance has been encountered, a good cosmetic result without risk of damage to the skin may be expected.

Vol. 42, No. 5

IRRADIATION WITH SMALL DOSES IN THE TREATMENT OF FUNCTIONAL GYNECOLOGICAL CONDITIONS*

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BASED upon the biological effect of roentgen rays and radium on human tissues and organs, an entirely new system of therapy has been developed employing these agents. At first only the destructive effects of radiation were considered of therapeutic value. Now, since we have a better understanding of the physiological response of body functions to radiation, roentgen and radium therapy are employed to control various endocrine dyscrasias and dysfunction of vital organs.

Functional disturbances associated with gynecological conditions were among the first of the abnormal phases effectively treated with irradiation. Because this procedure was originally found to be a specific therapy for suppressing menstruation, many regarded it as logical that if properly employed in smaller dosages it might, instead of suppressing the menses, stimulate these functions which, for some reason, were dormant or sluggish. Thus it was that roentgen therapy was suggested for the treatment of amenorrhea and sterility.

In many women who are desirous of bearing children, when all other efforts have failed to bring about this result roentgen therapy in many instances has proven effective. Amenorrhea, when due to functional disturbances, is also amenable to roentgen therapy.

In the course of our work in a large general hospital, we are asked to treat by irradiation numerous benign and malignant conditions, and among these patients are women who have for long periods been treated with various medications for amenorrhea and sterility but without avail. It is in such cases that roentgen therapy very often provides a cure, and in 1930 and again in 1931 we published a report of successful results from such therapy in a small group of cases. The present study indicates the results in the treatment of 194 married women who suffered with persistent amenorrhea and sterility. In this group, 131 cases were seen in private practice, and 63 were cases referred to the radiation therapy service at Bellevue Hospital.

The results of our study have served to strengthen our belief that in no other field of gynecology is irradiation more helpful and promising than in the treatment of functional disturbances of the ovary and in sterility.

In 1926 Rubin reported successful results in the treatment of patients with amenorrhea and sterility with roentgen irradiation. In 1927 Seitz reported 118 successful results in 209 cases of amenorrhea treated in this manner. Recently Mazer and Spitz reported beneficial results in 50 per cent of cases in their series treated for sterility.

As to the explanation of the action of the roentgen rays, this is not quite understood, but several apparently plausible explanations may be noted.

Although as long ago as 1905 Halberstädter first demonstrated the definite sensitivity of the ovaries to roentgen rays, the reaction has not as yet been fully made clear, nor the biological action on the ovary entirely explained. We do not yet know the real cause of menstrual bleeding, although recent endocrinological studies have shown an undoubted relationship between the pituitary, thyroid, and ovary. This interrelationship has been recognized for many

* Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

years, but only recently did Hartman and his coworkers definitely demonstrate that the pituitary is concerned in menstrual bleeding. Crossen and Crossen state that ovarian function is activated by the pituitary and the latter by other endocrine influence. Lacassagne holds that one-third of the anterior lobe of the pituitary is alone sufficient to preserve genital activity and that a definite minimum of anterior lobe is required to maintain normal physiologic balance of ovarian function. Johnstone states that the cause of amenorrhea is a very complex affair and must be something that activates the whole triangular mechanism of the pituitary, the ovary and the uterus.

At present we are inclined to attach prime importance to the pituitary as the factor controlling menstrual function. Does roentgen irradiation of the ovaries activate that "bleeding factor" of the anterior pituitary which then produces menstrual bleeding, as suggested by Wilson and Kurzrok? It is evident that normal genital function of the female depends upon the proper correlation between the pituitary, the ovary and the uterus. Aschheim and Zondek have proved that the pituitary produces its effect only when the ovary is present. Allen states that the anterior pituitary controls and maintains the action of the ovaries and Novak ascribes this control to the gonadotropic hormones produced by the basophile cells.

Béclère was the first to report the effect of roentgen irradiation on the pituitary. Lacassagne has shown that the anterior lobe of the pituitary is most resistant to destruction by irradiation, and therefore therapeutic irradiation of the pituitary is not harmful. Werner found that roentgen treatment of the pituitary stimulated menstrual reaction and because of this so-called stimulative action Borak suggested pituitary irradiation for mitigating climacteric symptoms of early menopause.

Frank states that in the normal, mature, fertile woman the ovary secretes two hormones, the estrogenic factor and the progestational factor, and that normal genital function is dependent on the synchronism of pre-pituitary estrogenic and progestational blood cycles. Mazer agrees with Frank that the normal menstrual cycle depends upon the balanced activity of the two ovarian hormones. Mazer and Andrussier emphasize the definite dependence of ovarian function upon hormonal stimulation from the pituitary. Corner states that progestin, the hormone of the corpus luteum, will help cases of sterility and habitual abortion, caused by lack of corpus luteum as it acts as a menstruation suppressor. Allen says experiments have shown that surgical removal of the corpus luteum brings on menstruation. Cystic conditions of the ovaries may readily produce amenorrhea or sterility, and, as Stein and Leventhal have shown, endocrine therapy is of little avail in such conditions, mechanical means constituting the only procedure for relieving the condition.

Although roentgen treatment to the pituitary alone appears to be efficacious, it does not account for the favorable results in all our cases as only 18 received this treatment.

Does roentgen radiation act mechanically, as in the case of polycystic ovaries which are relieved (Stein and Leventhal) by mechanical destruction of the cysts? In our series, one case had cystic ovaries proved at operation. Sterility was relieved by roentgen therapy, perhaps by destruction of the cysts. Does it destroy the corpus luteum which suppresses menstruation, according to Corner, or does it stimulate general normal interchange of hormones which produces normal pituitary, ovarian and uterine function and thus allows for menstruation and subsequent pregnancy?

Hutton and his coworkers, in their study of the action of roentgen rays on the mechanism of blood pressure control have definitely shown that the rays have an appreciable effect on the endocrine system. In our own observations we have noted that irradiation of the ovaries in castration doses inhibited epileptic attacks which ac-

companied normal menstruation, suggesting some relationship to the brain. The effect upon the rest of the endocrine system, if applied to the ovaries, may also be assumed to be reciprocal.

Wilson and Kurzrok state that actual bleeding occurs only if the bleeding hormone is not inhibited by the corpus luteum hormone. Does the roentgen ray destroy this inhibitory function of the corpus luteum? In our series in which 51 patients became pregnant following roentgen treatment, 10 cases had had previous pregnancies, 6 of whom bore normal children and 4 miscarried. Perhaps these had a persistent corpus luteum which inhibited menstruation and caused subsequent sterility. Roentgen therapy by destroying the corpus luteum, permitted these patients to menstruate, conceive and deliver normal children. Mazer and Andrussier state that organotherapy is far less effective than irradiation of the affected endocrine glands in the successful reestablishment of menstrual periodicity. Taylor likewise has shown that organotherapy is of little value in controlling mastitis associated with menstrual disorders, and states that roentgen therapy is often of definite therapeutic value in this condition, the irradiation achieving the result through the endocrine system.

Wolf, investigating endometrial biopsies obtained from cases of amenorrhea, states that the symptoms may be the result of: (1) Absence of function of the anterior pituitary lobe where the gonadotropic hormones originate. The endometrium is atrophic. (2) Excessive amount of follicle stimulating hormone, producing single or multiple granulosa cysts in the ovary without corpus luteum formation. The endometrium is hyperplastic (polyhormonal amenorrhea of Zondek). (3) Excess of luteinizing gonadotrophic hormone which results in a persistent cystic corpus luteum of the ovary. The endometrium is in the pre-menstrual phase.

In Wolf's opinion roentgen therapy directed to the pelvis is of no avail in Group 1, yet we have very numerous instances of apparent stimulation of pituitary function in this group. In Group 2 the roentgen ray, he states, destroys the persistent follicle, resulting in anovulatory bleeding and the results are generally good. In the third group, roentgen irradiation, by destroying the persistent corpus luteum, causes bleeding from a pre-menstrual endometrium. In our work with the treatment of neoplasms we have had frequent examples of actual tissue destruction by roentgen irradiation and can readily conceive of such a result on the follicle cysts.

Whether roentgen irradiation directly affects the ovary, the uterus, or the pituitary, or is an indefinite endocrinological factor stimulant is debatable. None the less, the fact remains that it has been a definite factor in the successful treatment of the cases herein reported.

In our opinion no other treatment so far devised, including organotherapy, has yielded as satisfactory or equally good results. The early enthusiasm aroused by endocrine studies along this line has so far been followed by disappointment. Stein and Leventhal have shown that endocrine therapy is of no avail in cases of cystic ovaries, amenorrhea and sterility. Many of our patients were given irradiation only after prolonged endocrine therapy had proved unavailing.

In all instances some form of endocrine therapy, including tablets of ovarian substances and the newer hormonal substances, had been used and found unavailing. All the cases had previously been examined for gynecological abnormalities. In many histories previous tubal insufflation was recorded and in a large number of instances the husband had been examined for potency. Kleegman stresses the importance of examining the male before treating the female for sterility, for quite often infertility is in the male and not the female.

In a number of cases previous surgical corrective measures or curettage was carried out without relief of symptoms.

TABLE I

DETAILS OF 38 MARRIED WOMEN WHO WERE TREATED WITH ROENTGEN THERAPY FOR AMENORRHEA AND STERILITY AND WHO SUBSEQUENTLY BORE NORMAL CHILDREN

Name	Age	Amenorrhea	Years of Sterility	Previous Children	Previous Abortions* or Miscarriage	Previous Operations	Results	
							Normal Children	Abnormal Abortion
A	28	6 mo.	4½	0	0	0	1 girl	
A	28	1 mo.	2	0	0	0	1 girl	
B	22	3 mo.	1	0	1	0	1 girl	
B	24	7 mo.	4	0	1	Curettage	2 boys	
B	24	3 mo.	4	0	0	0	1 girl	2 self-abortion
B	27	6–8 mo. scanty	3	0	0	Curettage	1 boy	
B	29	Irreg. 6–8 mo.	3	0	0	0	1 boy	
C	26	Irreg. 1 mo.	6	0	0	0	1 boy	
C	26	13 mo.	5	0	0	0	1 boy	
C	30	Irreg. 1 mo.	8	1 stillbirth	0	0	1 boy	
D	32	Irreg.	6	Married at 14, 3 children	0	0	1 girl	
E	29	3 mo.	7	1 6 yr. old	0	Cauterization of cervix	1 boy	
F	28	13 mo.	3	0	0	0	2 boys	
F	29	Irreg. 2 mo.	3	0	0	0	1 boy	
G	21	Irreg. 3 mo.	1	0	0	0	1 girl	
G	27	Irreg. 3 mo.	3	0	0	0	1 girl	
G	30	8 mo.	3	0	1	0	2 girls (twins) 1 boy	
G	34	Irreg.; scanty	4	0	0	For infantile uterus cystic ovary—curettage	1 girl	
I	24	Irreg. 1 yr.	3	0	0	0	2 boys	
J	30	14 yr.	5	0	0	0	1 boy 11 girl died in 4 days	
K	31	Irreg. 3 mo.	2	0	0	0	2 boys	
L	22	Irreg. 5–8 mo.	2	0	0	0	1 girl	
L	25	Irreg. 5–6 mo.	3	0	0	Curettage	1 girl	1 abortion
L	27	Irreg. 2–6 mo.	8	0	0	0	1 girl	
M	24	11 mo.	3	0	0	Curettage	1 boy 2 girls	
M	21	Irreg. 3 mo.	2 yr. married. Treated when single	0	0	Hormones for 6 mo.	2 boys	1 ectopic
M	23	5 mo.	3	0	0	0	1 girl	1 self-abortion
M	25	Irreg. 2 mo.	4	0	0	0	1 girl	
M	34	Regular	3	0	0	0	1 girl	1 miscarriage
O	30	Irreg. 2 mo.	6	1 stillbirth	0	Electric	1 girl	2 miscarriage
R	22	Irreg. 1 mo.	6	0	0	0	1 boy 1 girl	
R	28	Irreg. 1–3 mo.	6	0	0	0	2 boys	
S	24	3 mo.	5	0	0	0	1 girl	
S	24	3 mo.	2	0	0	0	1 boy	
S	31	12 mo.	8	0	0	0	1 boy	
S	33	Irreg. 1–4 mo.	17	0	0	Curettage	2 boys 1 girl	1 self-abortion
U	28	Irreg. 3 mo.	8	0	0	0	1 girl	
M*	31	Irreg. 6–12 mo.	12	0	1	0	1 boy	

* Previously included in aborted cases—subsequently successfully delivered.

Treatment in all cases was limited to irradiation with high voltage roentgen therapy administered in small doses to the ovaries. In many of the cases additional roentgen therapy was given to the pituitary and in a few instances to the thyroid.

The factors used were: 200 kv., 4 ma., with 0.5 mm. Cu plus 1 mm. Al filter, with a target distance of 30–40 cm., and treatment directed through anterior and posterior right and left pelvic fields of 9×12 cm.–12×15 cm. and to the pituitary area on the skin through a 6×8 cm. field. The dose given was 75–150 r (measured in air), per field, at weekly intervals, for three weeks. The anterior pelvis was treated the first week, the posterior the second week and the anterior the third week. Occasionally a fourth treatment was given. The pituitary was treated at the same session as the anterior pelvis.

All cases received roentgen therapy to the pelvis and 104 cases received additional treatment to the pituitary. In 6 cases the thyroid also was treated.

ANALYSIS OF CASES

Our present report is based upon a study of 131 married women who were referred to us in private practice, and 63 in clinic service during the period from 1924 to 1937 for treatment of amenorrhea or sterility. A substantial number of cases of single women treated by us for amenorrhea are not considered in this study. We have follow-up records on 117 private patients. Whether some of the 14 who could not be traced responded to the treatment or not they are regarded by us in this study as failures. While follow-up was possible in most of the private cases, unfortunately in the clinic it could be done only in 39 cases because of the economic and social status of patients in this group. Of the 194 cases treated, 159 were followed up and of these the menses were regulated in 103 cases, while in 56 there was no improvement. The oldest patient treated was forty-five years of age and the youngest nineteen. The results were most successful in the twenty-one to twenty-nine year group, and the next in the thirty to forty-five year group. It was noted that the younger the patient, the more amenable to the treatment

The amenorrhea suffered by the patients herewith reported extended for periods of from one month to fourteen years and the sterility from one to eighteen years.

Some of the women treated suffered amenorrhea or sterility subsequent to previous pregnancies. In 33 cases previous pregnancies had occurred, in 17 of these pregnancy with abortion or miscarriage had occurred.

RESULTS

Of the 103 patients whose menstruation was reëstablished, 51 cases became pregnant. In 52 instances no pregnancy occurred. Of the 51 cases that conceived one is at present in the course of her pregnancy.

In the private group there was 131 married women, of whom 117 were followed up. In 79 cases, or 60 per cent, the menses was restored; in 52 cases there was no improvement. Of the 79 successful cases, 44 women conceived, 17 more than once, 5 conceived but aborted and of these 2 aborted twice. Thirty-eight women went to term and gave birth to 50 living children. One went to term and gave birth to an abnormal fetus. One woman had twin girls, both physically and mentally normal, 9 women had more than one child. In this group there were 27 boys and 23 girls. Reports from the parents have in no instance disclosed any abnormalities or physical deformities in these children. The oldest child is now twelve years of age.

In the clinic group there were 63 cases, 39 of whom were followed up. Of the 39 cases, in 24, or 61 per cent, the menses were restored; in 15 there was no improvement. Of the 24 successful cases 7 women conceived, 3 bore normal children, one woman had a stillbirth, one is pregnant at present, and 2 became pregnant, delivered but did not subsequently report to the clinic.

None of the patients treated were harmed in any way. In no case did men-

struation cease where menstruation had previously occurred in the usual manner.

However, there unfortunately still exists among the profession a definite prejudice against irradiation for therapeutic purposes because of certain misconceptions or hearsay evidence in regard to alleged uncontrollable harmful effects upon both mother and offspring, and these misconceptions have caused the profession to ignore the successful results obtained by irradiation.

While it is true that roentgen therapy is frequently harmful to the unborn child when administered to a pregnant mother, the harm depending to a great extent on the age of the embryo and the amount of radiation given, perfectly healthy children have nevertheless been born to mothers who were irradiated for malignant conditions during the course of pregnancy. In 1930 we reported one such case and recently Neil, reporting a fortunate outcome in several of his cases, also cited several instances reported by others.

In our service we have had an untoward effect but once, which we reported in 1932. In this case treatment was administered when there already existed an embryo *in utero*, and the effect of roentgen rays upon the embryo is profoundly different from that upon unimpregnated ova.

Because of the successful results secured through irradiation in the large number of cases in our series, with subsequent follow up of children born of irradiated mothers, we feel warranted in reiterating our previous conclusions that irradiation, when properly given, is harmful neither to the mother nor to the offspring, and that it has proved a valuable therapeutic procedure for treatment of amenorrhea and the relief of sterility.

SUMMARY AND CONCLUSIONS

Roentgen therapy is of definite value in the treatment of functional disturbances of the ovary and in sterility. Irradiation is applied to the pelvis in most instances, and in some cases, to the pituitary as well. Whether to treat only one or both is a matter of judgment, based on training and experience.

Careful observation over a number of years of children born of mothers so irradiated shows that such children are in nowise abnormal physically or mentally.

REPORT OF CASES

Case I. C. A., June 9, 1925, aged twenty-eight, married two years. Menstruated at eleven, always irregular.

Roentgen Treatment: Anterior right and left pelvis 200 r
Posterior right and left pelvis 180 r

Result: Regular menstruation followed, became pregnant and a normal baby girl born January, 1927.

Case II. E. A., April 16, 1929, aged twenty-eight, married 4½ years. Menstruated at seventeen, regular first year, no menstruation second year, irregular thereafter, three to four times per year. Last period October, 1928.

Roentgen Treatment: Anterior right and left pelvis 200 r
Posterior right and left pelvis 150 r
Pituitary 150 r

Result: Regular menstruation until October, 1935, when pregnancy occurred and baby girl was born July, 1936. Regular menstruation following.

Case III. B. B., May 10, 1927, aged twenty-four, married four years. Menstruated at 12½ years, regular till marriage then stopped for a while then began menstruation again, irregular three to six months. Previous period October 5, 1926. Miscarried February 22, 1926, at three months, curetted plus biologicals. Retroverted uterus, enlarged right ovary, obese.

Roentgen Treatment: Anterior right and left pelvis 180 r
Posterior right and left pelvis 180 r
Pituitary 75 r

Result: Menstruated regularly for nine months, then became pregnant, baby boy born November, 1928. Second boy born May, 1934 (see Fig. 1).

Case IV. E. B., October 25, 1935, aged twenty-nine, married three years. Menstruated at fourteen, regular for eight years, then irregular six to eight months at a time. Treated with endocrines, no result.

Roentgen Treatment: Anterior right and left pelvis 160 r
Posterior right and left pelvis 85 r
Pituitary 190 r

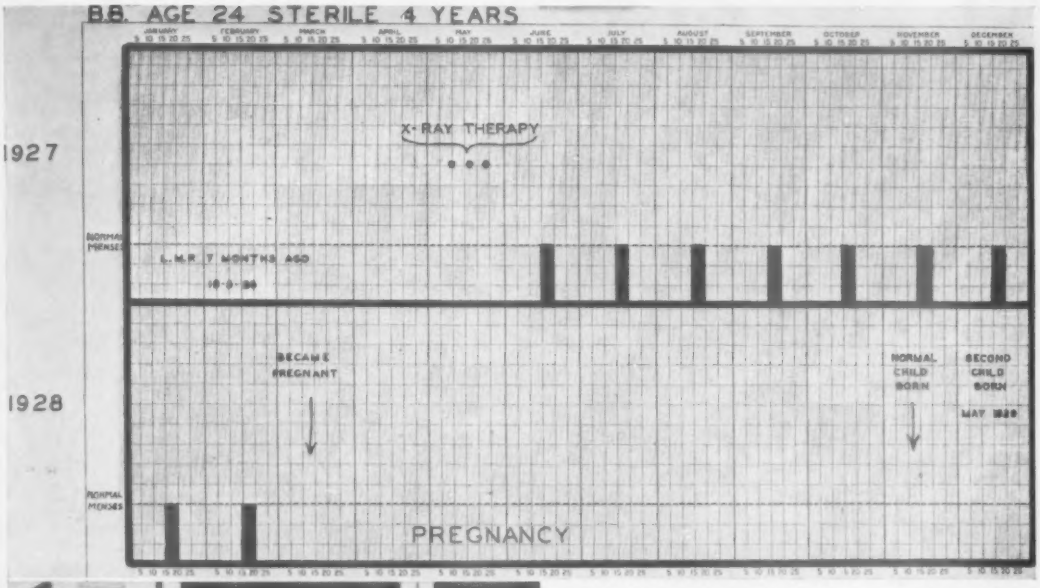

Fig. 1. Case III.

Result: Normal menstruation, December 12, 1935, then became pregnant; normal baby boy born December 17, 1936. Regular menstruation since.

Case V. H. B., March 12, 1925, aged twenty-two, married one year. Menstruated at 13½ years, always irregular ,miscarried August, 1924, then menstruated at three month interval, last period January, 1925.

Roentgen Treatment: Anterior right and left pelvis 150 r
Posterior right and left pelvis over a two week period. 150 r

Result: Menstruated once after treatment, then became pregnant; normal baby girl born January 16, 1926; regular menstruation since.

Case VI. M. B., October 10, 1927, aged twenty-four, married four years. Menstruated at sixteen, always irregular three to four months, last period July 4, 1927. Had insufflation test May, 1927, glandular extracts.

Roentgen Treatment: Anterior right and left pelvis 150 r
Posterior right and left pelvis 150 r

Result: Regular menstruation until December, 1927, became pregnant; normal baby girl born August, 1928, subsequent regular menstruation. Pregnant May, 1929, and January, 1926, with self-abortion. Regular menstruation at present (see Fig. 2)

Case VII. B. C., October 27, 1927, aged twenty-six, married five years. Menstruated at 12½, irregular three to five months, worse after marriage, last period September, 1926, amenorrhea for thirteen months, previous period September, 1925. Obese; weighs 145 pounds, body somewhat hairy.

Roentgen Treatment: Anterior right and left pelvis 120 r
Posterior right and left pelvis 180 r

Result: Regular menstruation, normal baby girl born November 27, 1928.

Case VIII. F. C., October 14, 1927, aged thirty, married eight years. Menstruated at fourteen, regular. August, 1926, stillborn child full term, scanty menstruation thereafter, sterile. Large fat woman.

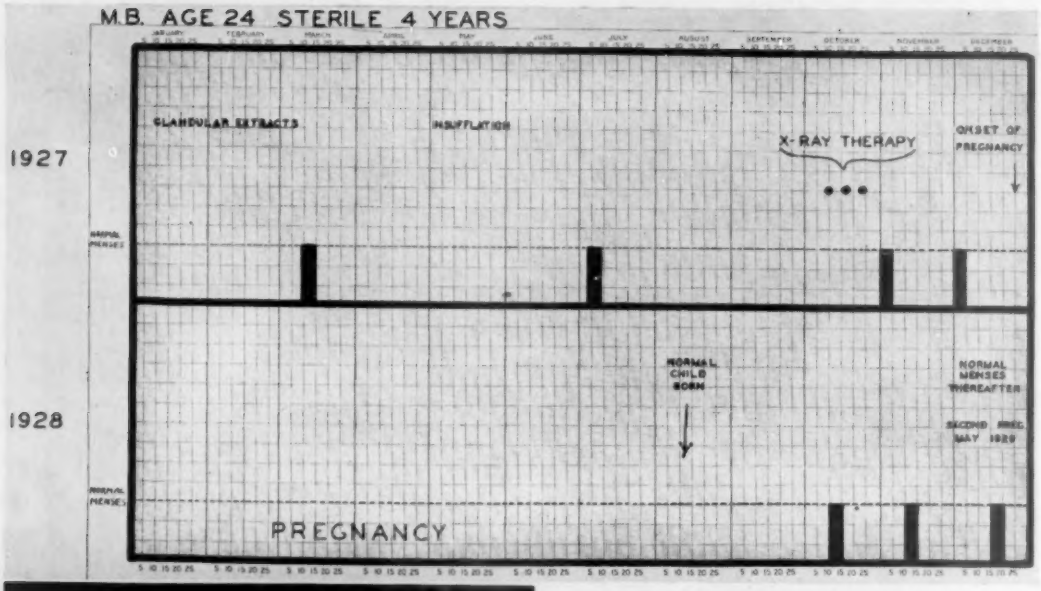

Fig. 2. Case vi.

Roentgen Treatment: Anterior right and left pelvis 180 r
Posterior right and left pelvis 180 r

Result: Menstruated regularly until May, 1930, became pregnant; caesarean section delivery, normal baby boy March 18, 1931, regular periods since.

Case ix. Y. C., April 20, 1930, aged twenty-six, married six years. Menstruated at fifteen, irregular, intermittent, last period March 15, 1930, obese, weighs 172 pounds.

Roentgen Treatment: Anterior right and left pelvis 180 r
Posterior right and left pelvis 180 r
Pituitary 90 r

Result: Regular menstruation for three months followed by pregnancy, normal baby boy born May 8, 1931.

Case x. B. E., April 6, 1927, aged twenty-nine, married seven years, has one child six years of age. Menstruated at eleven, always irregular, last period March, 1927, previous period October, 1926. Stout woman weighs 154 pounds. Retroverted uterus, erosion of cervix, cervix cauterized, ovaries normal.

Roentgen Treatment: Anterior right and left pelvis 180 r
Posterior right and left pelvis 180 r

Result: Regular menstruation till July, 1927, became pregnant and gave birth to a normal baby boy April 4, 1928, and is now menstruating regularly.

Case xi. G. F., April 8, 1927, aged twenty-nine, married three years. Menstruated at thirteen, always irregular three to nine months. Painful breasts with menstruation. Last period February, 1927.

Roentgen Treatment: Anterior right and left pelvis 180 r
Posterior right and left pelvis 180 r

Result: Menstruated for two months, became pregnant, normal baby boy born March 15, 1928. Second pregnancy 1929 and miscarried at fifth month; accidental.

Case xii. S. F., April 13, 1931, aged twenty-eight, married three years. Menstruated at fourteen, always irregular six to nine months, painful menstruation and painful intercourse, nervous, breasts swell and pain with menstruation. Enlarged thyroid, pulse 95, slight tremor.

Roentgen Treatment: Anterior right and left pelvis 150 r
Posterior right and left pelvis 120 r
Pituitary 150 r

Result: Regular menstruation for three months followed by pregnancy and normal baby boy, instrument delivery, March 26, 1932. Subsequent history—slight tremor, increased nervousness, enlarged thyroid; blood pressure 110/70; pulse 84.

Roentgen Treatment: 600 r to the thyroid over four weeks—beneficial.

Result: Second baby boy born June, 1935.

Case xiii. A. G., September 27, 1929, aged twenty-seven, married three years. Menstruated at fifteen, irregular three month intervals, last period July 10, 1929. Pain with periods. Obese, weighs 167 pounds.

Roentgen Treatment: Anterior right and left pelvis 180 r
Posterior right and left pelvis 150 r
Pituitary 25 r

Result: Menstruated October, pregnant November, delivered normal baby girl July, 1930.

Case xiv. G. G., February 18, 1932, aged twenty-one, married one year. Menstruated at thirteen, irregular, three months, scanty, occasional hot flushes, very nervous, tall thin woman.

Roentgen Treatment: Anterior right and left pelvis 120 r
Posterior right and left pelvis 90 r
Pituitary 60 r

Result: Menstruation regular, four days each for four months. Full term baby girl born March, 1933, regular menstruation since.

Case xv. I. G., September 17, 1926, aged thirty, married three years. Menstruated at twelve, regular till age of twenty-two then irregular, last period May, 1926, scanty. Miscarriage September, 1924, curettage July, 1925.

Roentgen Treatment: Anterior right and left pelvis 170 r
Posterior right and left pelvis 150 r
Pituitary 100 r

Result: Menstruated for four months; November, 1927, gave birth to twin girls, normal. Menstruated normally following delivery. September 14, 1930, gave birth to a baby boy not quite full term.

Case xvi. M. G., January 24, 1929, aged thirty-four, married four years. Menstruated at eleven, always irregular and scanty. In 1920 operated upon for infantile uterus, right ovarian cyst. Married at thirty in 1925, menstruation worse, last period January 18, 1929, for one day. Getting stouter, frequent hot flushes, weighs 135 pounds, quite stocky.

Roentgen Treatment: Anterior right and left pelvis 175 r
Posterior right and left pelvis 150 r
Pituitary 100 r

Result: Resumption of normal menstruation for two months. Baby girl born December 1, 1929, caesarean section.

Case xvii. S. I., October 22, 1924, aged twenty-four, married three years, no pregnancies. Menstruated at thirteen, regular at first then irregular. Last period October 4, 1923. Gaining in weight.

Roentgen Treatment: Anterior right and left pelvis 300 r
Posterior right and left pelvis 120 r
Pituitary 60 r

Result: December 2, 1924, menstruated; February, 1925, pregnant. Baby boy born October, 1925. Menstruated April, 1926, second baby boy born April 26, 1927. November, 1925, menstruating normally.

Case xviii. L. J., July 8, 1927, aged thirty. Menstruated at sixteen, irregular; menstruated twice then; no menstruation for fourteen years. Married five years, no menstruation. Insufflation, tubes open.

Roentgen Treatment: Anterior right and left pelvis 130 r
Posterior right and left pelvis 125 r
Pituitary 75 r

Result: Menstruation irregular for three months; June, 1931, delivered stillborn term baby boy. October, 1933, delivered baby boy normal. October 1935 delivered baby girl, died four days. Irregular menstruation followed, developed eye trouble partially blind in one eye, roentgen therapy over pituitary (diagnosed tumor).

Case xix. L. K., March 18, 1926, aged thirty-one, Menstruated at fourteen, irregular, last period December 31, 1925. Insufflation twice.

Roentgen Treatment: Anterior right and left pelvis 150 r
Posterior right and left pelvis 150 r

Result: Menstruated in June; August, 1926, pregnant. March 20, 1927, normal baby boy born, weighed 7 pounds 7 ounces. June 28, 1929, second baby boy born. In 1936 menstruating normally.

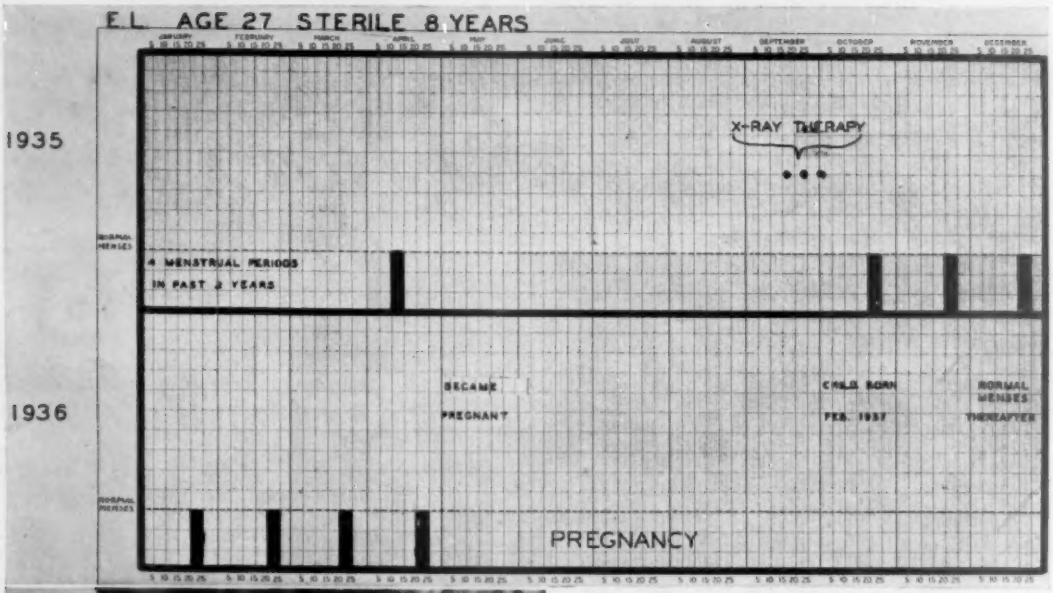

FIG. 3. Case xx.

CASE XX. E. L., September 17, 1935, aged twenty-seven, married nine years. Menstruated at twelve, regular till four years after marriage, then irregular. Had two years of persistent treatment with endocrines, menstruated only four times, sterile eight years.

Roentgen Treatment: Anterior right and left pelvis 235 r
Posterior right and left pelvis 80 r
Pituitary 100 r

Result: Normal menstruation resumed until May, 1936; pregnant, delivered normal baby girl February 3, 1937. Regular menstruation since (see Fig. 3).

CASE XXI. J. L., April 2, 1935, aged twenty-two, married two years. Menstruated at fourteen, always irregular two months, following marriage three months amenorrhea. Increased weight, last period December 8, 1934. Uterus small and posterior.

Roentgen Treatment: Anterior right and left pelvis 250 r
Posterior right and left pelvis 90 r
Pituitary 150 r

Result: Regular menstruation, normal baby girl born March 30, 1936; menstruation regular since.

CASE XXII. R. L., October 1, 1928, aged twenty-five, married three years. Menstruated at thirteen, regular till 1923, then irregular. Married, 1925, irregular five to six months with severe pain. In 1926 curettage, insufflation test, glandular treatment, no result.

Roentgen Treatment: Anterior right and left pelvis 180 r
Posterior right and left pelvis 150 r
Pituitary 90 r

Result: Regular menstruation until April, 1929, became pregnant and aborted. July, 1929, again pregnant; April 5, 1930, normal baby girl born. Irregular five to six week intervals, no pregnancies.

Roentgen Treatment: In February, 1933, posterior right and left pelvis 120 r, pituitary 200 r over a period of two weeks.

Result: Normal menstruation, fibroid uterus, no pregnancies.

CASE XXIII. A. M., March 20, 1931, aged thirty-four, married three years. Menstruated at sixteen, regular. Had Rubin test, no pathology.

Roentgen Treatment: Anterior right and left pelvis 200 r
Posterior right and left pelvis 150 r
Pituitary 200 r

Result: Normal menstruation. Baby girl born February 28, 1932. Pregnant again February, 1933; miscarried April, 1933; regular menstruation since.

Case xxiv. B. M., January 29, 1931, aged twenty-three, married three years. Menstruated at fifteen, regular for one year then irregular until 1927; married December, 1927; periods twice per year, last period August, 1930.

Roentgen Treatment: Anterior right and left pelvis 155 r
Posterior right and left pelvis 125 r
Pituitary 125 r

Result: Menstruated March, April, May, pregnancy occurred in June, 1931. Normal baby girl born February 21, 1932, weight 8 pounds 3 ounces. Menstruated regular. February, 1934, pregnant again, self-aborted followed by irregular menstruation. January, 1935, curettage, regular periods, gaining in weight.

Case xxv. M. M., February 22, 1927, aged twenty-four, Italian, married three years. Menstruated at 12½, irregular two to five months, did not improve with marriage. Last period March, 1926, scanty for two days. Curetted November, 1925, plus glandular treatments, weighs 153 pounds and getting stouter, occasional hot flushes. Short and stout; considerable hair on body.

Roentgen Treatment: Anterior right and left pelvis 200 r
Posterior right and left pelvis 200 r
Pituitary 100 r

Result: Menstruation regular; May, 1928, baby boy born, instrument delivery, baby weighed 6 pounds 6 ounces; August, 1930, baby girl born; July, 1934, normal baby girl born; menstruation regular now.

Case xxvi. L. M., May 13, 1929, aged twenty-one, single at this time. Menstruated at eleven, irregular three weeks to three months with dysmenorrhea. Hormone injections for six months. Last period February, 1929.

Roentgen Treatment: Anterior right and left pelvis 180 r
Posterior right and left pelvis 125 r
Pituitary 75 r

Result: Menstruation regular each month. Married, 1931, continued regular until pregnant in December, 1931; August 4, 1931, normal baby boy born and menstruation regular until second pregnancy, February 7, 1934, second baby boy born. In September, 1936, ectopic pregnancy occurred.

Case xxvii. M. M., February 21, 1927, aged twenty-five, married four years. Menstruated at thirteen, irregular two to three months, scanty. Last period December 6, 1926. Husband tested and found fertile. Rubin test.

Roentgen Treatment: Anterior right and left pelvis 180 r
Posterior right and left pelvis 180 r

Result: Menstruation normal until March, 1930; became pregnant in April and gave birth to a normal baby girl January 31, 1931.

Case xxviii. B.O'D., August 13, 1926, aged thirty, married six years. Menstruated at fourteen, always irregular. Last period June 2, 1926; one pregnancy with stillbirth in 1921, never pregnant after that. Had electric treatments to uterus and pills. Cystic left ovary.

Roentgen Treatment: Anterior right and left pelvis 200 r
Posterior right and left pelvis 150 r
Pituitary 100 r

Result: Normal regular menstruation. December 7, 1928, normal baby girl born; has had 2 miscarriages since. Periods regular.

Case xxix. E. R., October 10, 1928, aged twenty-two, married three years. Menstruated at twelve and a half; irregular and scanty, obese, dizzy spells.

Roentgen Treatment: Anterior right and left pelvis 180 r
Posterior right and left pelvis 150 r
Pituitary 60 r

Result: Regular menstruation, August 30, 1929, normal baby girl born, instrument delivery. August 2, 1931, normal baby boy born. Menstruation normal.

Case xxx. M. R., July 31, 1930, aged twenty-eight, married six years. Menstruated at twelve, irregular every three months; May and June, 1930, only spotted. Short stout woman.

Roentgen Treatment: Anterior right and left pelvis 125 r
Posterior right and left pelvis 125 r
Pituitary 90 r

Result: Following treatment menstruated in August, September; October 10, 1930, last period. July 17, 1931, delivered normal baby boy, menstruation normal. November 28, 1934, delivered second normal baby boy. Menstruation normal now.

Case xxxi. F. S., November 3, 1926, aged twenty-four, married three years. Menstruated at thirteen regular at first then irregular three to four times per year. Last period August, 1926. Uterus undeveloped. Moderate sized patient.

Roentgen Treatment: Anterior right and left pelvis 200 r
Posterior right and left pelvis 150 r

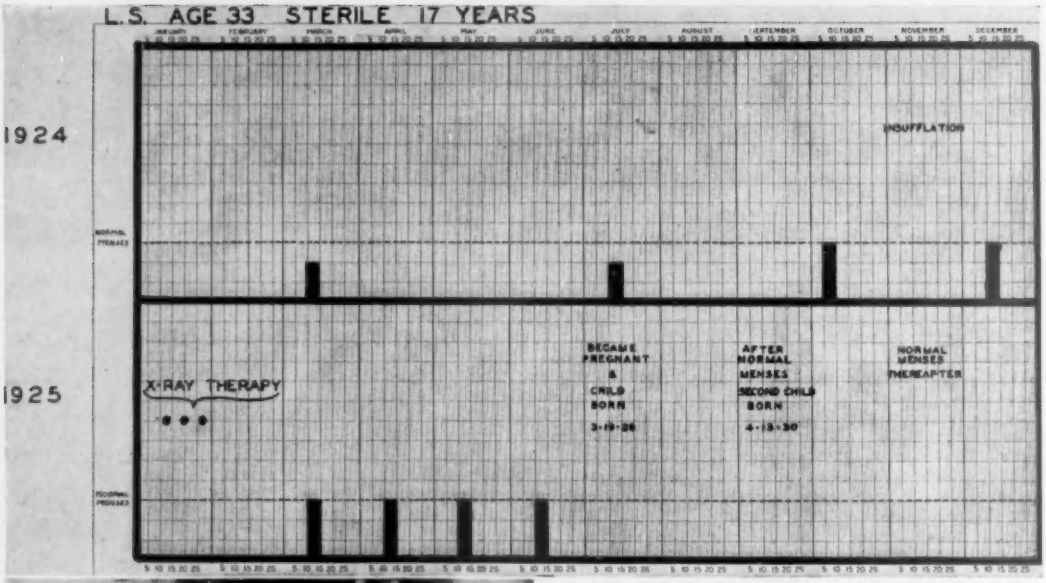

Fig. 4. Case xxxiii.

Result: Menstruated December, 1926, pregnant January, 1927; normal baby boy born August 2, 1927.

Case xxxii. L. de S., January 10, 1928, aged thirty-two, married fourteen years. Menstruated at thirteen, regular until the age of twenty-nine years then irregular. Three previous children, youngest six years old. Patient has flushes and dizziness. Large stout woman.

Roentgen Treatment: Anterior right and left pelvis 200 r
Posterior right and left pelvis 180 r

Result: Normal menstruation resumed. Normal baby girl born February 28, 1934. Regular menstruation since.

Case xxxiii. L. S., January 13, 1925, aged thirty-three, married seventeen years. Menstruated at eighteen years, always irregular, always bled with intercourse, never pregnant. In 1913 curettement and no menstruation for one year; irregular thereafter. Last period December 25, 1924, after insufflation, previous period October, 1924. Gaining weight, went to Europe for cure previous summer, no result. Right enlarged uterus somewhat tender. Stout woman.

Roentgen Treatment: Anterior right and left pelvis 200 r
Posterior right and left pelvis 200 r
Right and left thyroid 75 r

Result: Menstruated March, April, May and June then became pregnant, normal baby boy born March 19, 1926; nursed baby seven months, then menstruated eighth month, then nine weeks later became pregnant again and March 7, 1928, normal baby girl born, menstruation normal and April 13, 1930, second baby boy born; all children normal. February, 1931, pregnant, with self-abortion. November, 1935, patient reports normal menstruation (see Fig. 4).

Case xxxiv. M. S., May 24, 1926, aged thirty-one, married eight years. Menstruated at sixteen, always irregular, last period May, 1925. Insufflation, getting stouter had thyroid medication, hair on face.

Roentgen Treatment: Anterior right and left pelvis 100 r
Posterior right and left pelvis 100 r

Result: Menstruation for several months scanty, then regular for six years; in 1933 stillborn baby girl. Irregular menstruation followed. August, 1935, normal baby boy born. November, 1935, reports irregular menstruation.

Case xxxv. M. S., September 15, 1926, aged twenty-four, married five years. Menstruated at twelve irregular, three times per year. Last period July 23, 1926, painful. Small woman.

Roentgen Treatment: Anterior right and left pelvis 180 r
Posterior right and left pelvis 150 r
Pituitary 150 r

Result: Painful menstruation but regular. Normal baby girl born June 1, 1927.

Case xxxvi. M. U., August 12, 1927, aged twenty-eight, married eight years. Menstruated at thirteen, always irregular, last period May 13, 1927. Curetted in 1925; no benefit.

Roentgen Treatment: Anterior right and left pelvis 150 r
Posterior right and left pelvis 150 r

Result: Regular menstruation, normal baby girl born August 24, 1928.

Five Cases of Abortion

Case xxxvii. S. B., October 14, 1927, aged thirty-two, married nine years. Menstruated at thirteen, regular until twenty-one then irregular. Dilatation and curettage at twenty-four, last period January, 1927. Head flushes, weight 135 pounds, patient fat and quite hairy.

Roentgen Treatment: Anterior right and left pelvis 100 r
Posterior right and left pelvis 150 r

Result: Menstruation for two months then pregnant, self-aborted at three and a half months. Curettage. No menstruation.

Roentgen Treatment: Irradiated over the pituitary for 3 doses, 160 r over a two week period.

Result: Menstruated in June, 1929.

Case xxxviii. F. M., September 12, 1927, aged twenty-six, married six years. Menstruated at fifteen, irregular every three to four months, last period November, 1926.

Roentgen Treatment: Anterior right and left pelvis 180 r
Posterior right and left pelvis 150 r

Result: Menstruation regular until March, 1928 (five months); became pregnant, miscarried August, 1928. October, 1928, second pregnancy, aborted December, 1928. No pregnancy since then.

Case xxxix. F. M., October 25, 1926, aged twenty-three, married two years. Menstruated at thirteen, irregular eight to twelve weeks. Last period August 1, 1926.

Roentgen Treatment: Anterior right and left pelvis 200 r
Posterior right and left pelvis 150 r

Result: February 3, 1927, pregnant three months, self-aborted. Since then regular menstruation.

Case xl. M. M., May 6, 1935, aged thirty-one, married twelve years. Menstruated at fifteen, scant and irregular one to two times per year. Last period June 16, 1934, amenorrhea for one year. Gaining in weight, is now quite fat.

Roentgen Treatment: Anterior right and left pelvis 250 r
Posterior right and left pelvis 100 r
Pituitary 180 r

Result: Menstruation regular for two months, pregnant June, aborted December, 1935, about a six months fetus. Regular periods since. Pregnant again and baby boy born January 27, 1937 by caesarean section.

Case xli. R. P., January 21, 1925, aged twenty-four, married two years. Menstruated at sixteen, irregular. Amenorrhea seventeen months. Short fat, hairy woman.

Roentgen Treatment: Anterior right and left pelvis 150 r
Posterior right and left pelvis 100 r
Pituitary 150 r

Result: Menstruation regular till January, 1926; became pregnant and aborted March, 1926, a five weeks fetus. The patient has not been seen since that time.

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Vol. 42, No. 5

LOCAL ASPHYXIA AND ROENTGEN IRRADIATION OF TRANSPLANTABLE RAT TUMORS

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RADIOTHERAPY has been developed principally by empirical trials on human patients. While there are advantages in such a method of direct demonstration, there are nevertheless possibilities of error, and the process of final proof may be costly. It is only necessary to refer to the historical development of tumor therapy, with its successive methods of roentgen-ray application, each of which was sponsored by leading authorities and used on numberless patients throughout the world, until it was proved defective and replaced by something better. A dependable method of animal experimentation might offer more fundamental and exact information at less sacrifice.

Although information of this kind has actually been gained from irradiation of biological objects such as seeds, eggs, and various normal and tumor cells *in vitro*, these methods do not cover all clinical requirements. In 1923 and 1931, Wood discussed "Biological determination of radiation dosage," and "Animal tumors as therapeutic agents," concluding that results obtained with animal tumors could be confidently applied to human cases. The subsequent literature on this point is scanty and conflicting, as follows.

(*a*) Wood defined the lethal roentgen-ray dose for animal tumors as ranging from 3 to 7 erythemas, approximately the same as the extremes for human tumors. The most commonly used experimental strains are classed among the radioresistant group. Juul states that they can be killed only by doses which far exceed the tolerance of the normal tissues. Wood and Prime determined the death-points of tumors by implanting them in a fresh animal after irradiation, not expecting a cure in the sense of survival of the tissues of the original host.

(*b*) A group of authors (Frankl and Kimball; Clunet; Da Fano; Murphy; Russ, Scott, Chambers) have reported that the growth of tumors is retarded or completely prevented by irradiation of the normal tissues with doses much smaller than required for killing existing tumors; furthermore (Nakahara, Vorlaender; ref. by Juul) the histological changes in tumors receding under these conditions are identical with those which occur after direct irradiation of the tumors. Wood and Prime and several other investigators (ref. by Krebs and Juul) have ascertained that the same tumor is killed *in vivo* by lower roentgen-ray dosage than *in vitro*. Nevertheless it has been the prevalent doctrine that tumors are killed essentially by a direct action of the rays upon the cells, and believers in a reaction in the stroma or normal tissues as an im-important curative factor[14] have been in the minority.

(*c*) Wood arrived at the conclusion that the effect is due solely to the amount of radiant energy absorbed by the tumor cell, and that wave length and all other variables make no difference. Wedd and Russ (ref. by Krebs) were able to kill tumor cells *in vitro* with soft rays in thirty minutes but with hard rays only in two and a half hours. The development of practical radiotherapy is in the direction of increasingly high voltage and highly filtered rays for the sake of greater penetration.

METHODS AND PURPOSE

The procedure in the present investigation comprised the following:

(*a*) Albino rats were used, bearing transplantable tumors of three kinds, namely the Crocker Laboratory sarcoma No. 39, the Flexner-Jobling carcinoma, and the Walker tumor. The tumors ordinarily were in the hind legs, and were not used until

they had attained a considerable diameter, namely 1.5 to 3 cm. or sometimes larger. A difference from most research along this line lies in the use of larger tumors, also in the observation that spontaneous recession under these conditions is so rare as to be negligible, partly because of the smaller recessive tendency as compared with young small transplants, and probably also because of the firmer anchorage and better blood supply as compared with the usual axillary implantation.

(*b*) Experiments published elsewhere[8] showed that asphyxia of legs and other organs, produced by stoppage of circulation with a tourniquet or clamp for several hours, results in extensive sloughing of tumors in contrast to the mere inflammation in the normal tissues. Under the right conditions it is not difficult thus to obtain complete exulceration of all visible tumor tissue, but success in the sense of permanent healing without recurrence is variable. Mouse tumors seem to be among the most easily cured. In rats, most tumors recur after treatment and only a small minority are actually cured. Results appeared promising in one incomplete experiment with a spontaneous dog tumor. The chicken sarcoma sloughs readily but nearly always recurs. The only human case treated by asphyxia, namely a squamous cell carcinoma of the face, was cured. Various evidence indicated that the tumor destruction represents not a differential asphyxia of the tumor cells but rather a reaction in the normal tissues. The chief point of interest was whether asphyxia and irradiation can supplement or reinforce each other, with respect to either direct killing of tumor cells or reaction in the environment, so that tumors resistant to either method may perhaps succumb to the combination.

(*c*) Three changes in roentgen-ray equipment and operation were, in order of time, as follows. Through the kindly interest and permission of Dr. James Ewing, a series of rats was irradiated in the Memorial Hospital, New York, by Dr. Paul S. Henshaw, using hard rays from an apparatus of 200 kv. secondary voltage, 30 ma. tube current, and 50 cm. target-skin distance, filtered through 0.1 mm. copper and 4.0 mm. celluloid. A second series of rats was irradiated in the Polyclinic Hospital, New York, by Dr. A. Judson Quimby, who because of his preference for soft rays used an apparatus of 106 kv., 3 ma., and 20 cm. target-skin distance, without filtration. Still later, a third series of rats was irradiated in the Polyclinic Hospital by Dr. Frank Huber using newly installed deep therapy apparatus, with results similar to those of the first series. All the results are combined in the following presentation, except where distinctions are necessary. Cordial thanks are here expressed to all the above-mentioned doctors for their indispensable aid, also to various members of the Memorial Hospital staff for courtesies. Valuable technical assistance was rendered by Mr. James G. Rice.

I. Roentgen Irradiation of Normal Controls

No detailed review will be attempted of the very scanty data in the literature concerning the variable roentgen-ray tolerance in different animal species and in different bodily regions or organs. The rat's tolerance is known to be higher than the human, and these observations confirm the fact that it is considerably higher in old than in young rats; also, areas with thick skin and hair, such as the back, are more resistant than those with thin skin and hair, such as the groin and foot; but these differences have not been worked out mathematically.

In the first series, 15 young adult albino rats were given doses of the hard rays ranging from 1,000 to 7,000 r, limited to one hind leg. The epilation dose may be set approximately at 1,500 to 2,000 r, for amounts less than this caused only slight thinning of the hair. Even with 2,000 or 2,500 r the epilation was not total, for when the long hairs had fallen out there was still a sparse growth of short hair. There was increasing scaliness of the skin with these doses, and vesication began at about 3,000 r. This

vesication was slight and superficial, but on healing it left the first complete epilation in the sense of absence of all hair on skin which appeared normal otherwise. The limit of tolerance seemed to be about 3,500 r, which caused severe necrosis in the skin and deeper tissues; the end-result in some cases was loss of the leg by gangrene or mummification, in others healing and retention of a functional but atrophied leg. All doses of 4,000 r and above were followed by gradual death of all tissues and loss of the leg. The tolerance limit is set by the skin, for with some of these higher doses the skin sloughed off completely while the deeper tissues appeared merely inflamed and able to survive except for the lack of covering. The therapeutic possibilities are therefore essentially a question of the respective sensitiveness of the tumor and the skin.

With the soft rays in the second series, the tolerance was found approximately twice as high. Only erythema and partial epilation were encountered with doses from 3,500 r upward, until dangerous burns began at about 6,000 r, although several rats survived this dose with only temporary vesication and no complete or permanent epilation. The explanation seems not to lie in the manner of calculation of the soft ray dosage, because the apparatus was in constant clinical use and the human erythema dose was known to be about 500 r. On the other hand, the beam of hard rays was limited by lead shutters, the body of the rat was closely encased in lead, and the leg to be treated was stretched out over space with efficient precautions against back-scatter. In the experiments with both hard and soft rays, in both normal and tumor-bearing animals, the feet were ordinarily shielded because their tolerance is much lower than that stated for the legs.

2. NORMAL CONTROLS WITH IRRADIATION AND ASPHYXIA

The tolerance of normal tissues for twelve hours or more of local asphyxia, and the modifications with temperature changes and other conditions, have been described elsewhere.[1-7] The following results were obtained with the hard roentgen rays.

1,000 r. The legs receiving this dosage were subjected to ligation for graded periods from twelve down to four hours. The border line of tolerance was found at about six hours. One animal thus treated gnawed off a part of the foot; the slow healing required seven weeks. All longer ligations resulted in gangrene or death. Ligations of four and five hours were followed by full recovery.

2,000 r. Rats receiving this dosage underwent ligations from four to eight hours. The longest tolerance was for four hours, which ended sometimes in recovery, sometimes in deep ulceration followed by some atrophy but with retained function. All the longer ligations caused gangrene or death.

3,000 r. Rats with this dosage were given ligations of one to five hours. No legs were saved after more than two hours. There were mixed results of recovery and gangrene with both the one-hour and the two-hour ligations.

3,500 to 5,500 r. Single animals were subjected to various ligations after doses of 4,000, 4,500 and 5,500 r at the beginning, before the above-mentioned results were complete. It was noticeable from the outset that the roentgen treatment often modified the vascular reaction following ligation; the hyperemia was not so bright colored, and the swelling was smaller but harder. The first trials therefore covered the question whether roentgen irradiation might afford any protection against the results of ligation, and oppositely whether the great hyperemia following ligation might neutralize any of the injury from roentgen irradiation. All these largest doses were followed by gangrene or death. Also 3 animals receiving 3,500 r failed to tolerate two hours or one hour of ligation. Evidently the injury from 3,500 r is so great that the tissues are unable to survive the additional injury of any ligation whatever.

The experiments therefore show that the

tolerance of normal tissues for asphyxia is shortened even by small doses of roentgen rays, and is further reduced as the roentgen-ray dosage is increased.

Results similar to the above were obtained with the soft rays, merely with adjustment to the higher dosage mentioned under normal controls.

The usual method throughout these experiments was to give the irradiation in the forenoon and ligate the leg in the afternoon. No perceptible difference was introduced when this procedure was reversed, or when the irradiation was given during the course of the ligation, or immediately before or after it.

Table I

TREATMENT OF 69 LEG TUMORS WITH SINGLE ROENTGEN IRRADIATION AND LIGATION

Dosage	Tumors* (number and kind)	Length of Ligation (hours)	Results
500– 800 r	2 W	5–6	2 recurrences
1000 r	9 S		
	2 W	2–5	Both W recurred; 8 S cured; 1 recurred
1500 r	1 S		
	3 C	4–5	1 C recurred; 1 S and 2 C cured
	2 W	8–9	Cured
2000 r	1 S		
	2 C	4–5	1 early death; 2 cures
	10 W	7–9	2 early deaths; 1 recurrence; 7 deaths in 16 to 30 days without visible tumors (but with 3 metastases)
2500 r	5 S	3–4	4 early deaths, 6 cures
	5 C		
	17 W	4–8	6 early deaths, 4 recurrences, 7 cures (3 with metastasis)
3000 r	12 W	5–8	4 deaths in 8 to 14 days, with no tumor discernible; 6 deaths after 30 days, from metastases, without sign of original tumors; 2 complete cures

* C = carcinoma, S = sarcoma, W = Walker tumor.

3. TUMOR CONTROLS WITH IRRADIATION ALONE

The 3 series included a total of 63 rats treated with roentgen irradiation alone. In general the lower doses had little effect. Doses approaching the maximum tolerated by normal tissues regularly resulted in marked necrosis or recession of the tumor, not infrequently to the point of temporary or apparent cure, but followed ordinarily by renewed growth. The few permanent cures did not correspond to any particular method or dosage, though they were more numerous with the hard rays, and were not above 10 per cent in any group. Such a small percentage of cures, usually disregarded in experimental tumor literature, is here interpreted as genuine on two grounds: first, no such percentage occurred spontaneously among many hundreds of untreated animals; second, the roentgen-ray cures included only sarcoma No. 39 and the Flexner-Jobling carcinoma, never the Walker tumor, which was most resistant against all agencies. The most probable explanation seems to be that these cures are limited to tumors which are below average vigor, but not to the point of spontaneous recession. In a broad sense,

these three rat tumors are incurable by any single dose of roentgen radiation which the normal tissues can survive.

4. SINGLE TREATMENTS WITH ROENTGEN RAYS AND ASPHYXIA

Table 1 summarizes the results of treatment of 69 tumors treated with hard rays in combination with ligation. The number of permanent cures was high, but a compilation of percentages would be useless because the methods in individual cases were so variable. Still better results might be obtainable with practice and selection of the most favorable combinations.

Another series of 76 tumors treated with similar ligations together with soft roentgen rays up to 6,000 r appeared encouraging at first because of the extensive sloughing of the tumors with minimal disturbance in the normal tissues. Growth was finally renewed in the depths of most of these tumors, so that the final results were not demonstrably superior to those obtained with ligation alone.

The two most noteworthy points in this phase of the work seem to be, first, that a significant proportion of cures was obtained at least with the hard rays when reinforced with a method (asphyxia) which creates a reaction in the surrounding tissues; second, that the stoppage of circulation provides a means for retention of hypothetical radiochemical products in the tumor cells for a number of hours, but nevertheless there was no perceptible difference in results when the irradiation was given during, before or after the ligation. There is some analogy with the finding of Rohdenburg and Prime that heat increased the effect of roentgen rays on tumors, regardless of which one was given first.

TABLE II

ROENTGEN IRRADIATION AT LONG INTERVALS AFTER LIGATION

Dosage	No. of Days after Ligation	Tumors*	Length of Ligation (hours)	Results
1000 r	4	S	6	Recurrence
1500 r	5	W	7	Recurrence
	6	W	5	Recurrence
	7	C	6	Cure
2500 r	5	S	5	Cure
	9	W	7	Cure
3000 r	10	W	10	Cure
	6	S	5	Cure
3500 r	7	S	5	Cure

* C = carcinoma, S = sarcoma, W = Walker tumor.

5. INFLUENCE OF LONGER TIME INTERVALS

Control experiments showed that the resistance of the normal tissues to ligation or roentgen radiation increases as the time between the two forms of treatment is lengthened. The results with tumors are shown in Tables II and III.

Table II comprises only a small series of 9 tumors, treated with hard rays at intervals of four to ten days after ligation. A number of acute deaths are omitted. The reason for attaching any significance to such a small group is, as already stated, that these are established leg tumors above 2 cm. in diameter and practically free from spontaneous recessions. The results at least suggest strongly that the tissue reaction

excited by asphyxia continues in such a manner as to sensitize the tumor to irradiation for a number of days.

Table III summarizes 35 experiments in which the hard ray treatments preceded the ligations by one to twelve days. As neither form of treatment by itself sufficed to account for the proportion of cures, there is an indication of a delayed effect of the irradiation sensitizing the tumors to asphyxia.

The observations in general conform to the accepted rule that normal tissues recuperate more rapidly than tumors.

Table III

THIRTY-FIVE LIGATIONS AT LONG INTERVALS AFTER ROENTGEN IRRADIATION

Dosage	Tumors* (number and kind)	No. of Days after Irradiation	Ligation (hours)	Result
1000 r	4 S	1– 4	4–5	2 early deaths, 2 cures
1500 r	4 S 3 C	3– 7	3–5	2 recurrences (ligation on 18th and 31st day); 5 cures (ligation on 7th to 11th day)
2000 r	4 S 3 C 3 W	3– 9	3–7	4 early deaths, 4 cures, 2 recurrences
2500 r	5 S 3 C 1 W	4– 8	3–5	1 early death, 1 amputation, 2 recurrences, 4 cures (2 with metastases)
3000 r	3 W	6–12	4–5	3 cures (metastases in 1)
3500 r	2 S	7– 8	4	2 cures (vesication; permanent epilation)

* C = carcinoma, S = sarcoma, W = Walker tumor.

6. REPEATED TREATMENTS

Experiments were begun to test the applicability of this rule of differential recovery rate to the treatment of rat tumors.

Table IV presents the results of repeated applications of soft roentgen rays over varied periods of time. A detailed account of the individual doses and time intervals is omitted partly to save space and partly because the details appeared relatively unimportant, the governing factors being essentially the total radiation dosage within a given period. On the whole, the desired result of an increased proportion of cures with less injury to the normal parts was not obtained.

It was proposed to carry out another preliminary series of this kind with the hard rays, and then to combine both kinds of irradiation with ligation. The work was broken off when both these kinds of experiments were too few to warrant tabulation. The small group of experiments with the hard rays showed that their effect is more severe and prolonged, so as to limit the tolerance to a fraction of the large total dosage shown for the soft rays. The general results of the few ligation experiments were inferior to those obtained with single intensive treatments.

The enormously greater rapidity of growth of the rat tumors as compared with human tumors probably militates against the success of fractionated treatments.

7. IRRADIATION AND CONGESTION

In previous experiments,[8] congestion was produced by applying a ligature with enough tension to make a maximum blue

color in the tumor without stopping the arterial flow. Such congestion could be maintained much longer than complete asphyxia, and with much less injury to the normal tissues, but it proved ineffectual either to cure tumors or to increase the effects of preceding or subsequent tight ligation.

8. Asphyxia, Roentgen Irradiation and Fever

The indications for these experiments were: (1) the observations of several writers[12] that heat sensitizes tumors to roentgen radiation; (2) experiments published elsewhere[8] showing that heat increases the sensitiveness of tumors to asphyxia but also narrows the margin of safety in comparison with normal tissues; (3) the suggestive occurrence of high fever in most of the cases of recovery from inoperable malignant tumors recorded in the literature.[11,12]

No local applications of heat were undertaken. A warm-air chamber was used to produce rectal temperatures of 103 to 105° F. according to the method described elsewhere.[5] A large number of combinations of this form of fever with local ligation and

Table IV

Repeated Irradiations

Period (days)	Total Dosage (roentgens)	No. of Animals	Results	
			Tumor	Normal Tissue
7–14	3000–4000	3	2 cures, 1 uncertain	2 unchanged, 1 partial epilation
	6000–7000	22	12 partial necrosis, 6 complete, 4 cures	Slight erythema and epilation
	8500–9500	6	5 complete necrosis, 1 cure	4 vesication and partial epilation; 2 gangrene
	11,000	1	1 cure	Vesication; partial epilation
16–24	7000–8500	4	2 complete necrosis, 2 cures	Vesication; partial epilation
	9000–10,500	13	6 partial, 5 complete necrosis, 2 cures	Vesication; partial epilation
	11,000–12,000	9	1 partial, 6 complete necrosis, 2 cures	Vesication; partial epilation
	14,000–15,500	7	5 complete necrosis, 2 partial	Severe vesication 2 gangrene
	17,500	1	Complete necrosis	Gangrene of leg
28–33	9000–9500	2	Complete necrosis	Slight erythema
	11,000–12,000	4	2 partial, 1 complete necrosis, 1 cure	Slight erythema
	13,500–14,000	2	Complete necrosis	Leg mummified
	19,000	1	Complete necrosis	Vesication
50–66	15,000–16,000	3	Complete necrosis	1 slight erythema; 1 vesication, 1 mummification
50–60	18,000	6	5 complete necrosis, 1 cure	1 vesication, 5 gangrene

Table v shows the results of this form of congestion in combination with hard roentgen rays. The number of cures of large established tumors cannot be accounted for by the irradiation alone, and it must therefore be concluded that the tumors were made more susceptible by the prolonged congestion. A much larger series of experiments would have been necessary for an attempt to devise an optimum method which might give consistently successful results.

TABLE V

EIGHTEEN LEG TUMORS TREATED WITH ROENTGEN IRRADIATION AND CONGESTION

No.	Tumor*	Irradiation	Congestion	Results
1	S	1000 r	5 hr. on 1st, 18th and 38th days	Apparently complete exulceration after each treatment, but recurrence each time
2	W	1000 r on 1st and 2nd days	4 hr. on 1st and 2nd days	Death on 13th day, with healing ulcer and no visible tumor
3	W	1000 r on 1st and 2nd days	5 hr. on 1st, 2nd, and 3rd days	Death on 5th day. Tumor mostly necrotic, but small areas alive
4	C	1000 r	2 hr. 3 times daily for 5 days	Apparently complete exulceration; recurrence
5	W	1000 r	4 hr. daily for 5 days	Cure
6	C	2500 r	4 hr. on 1st, 8 hr. on 2nd day	Cure
7	C	2500 r	2 hr. on 1st, 8 hr. on 2nd day	Cure
8	W	2500 r	4 hr. once on 1st day, twice on 2nd day	Cure
9	W	2500 r	8 hr. on 1st, 4 hr. on 4th day	Cure. Leg hairless, atrophic
10	W	2500 r	2 hr. on 1st day, 5 hr. on 4th, 5 hr. on 9th day	Cure
11	W	2500 r	7 hr. on 1st day	Tumor disappeared. Death from metastasis in 36 days
12	W	2500 r	6 hr. on 1st and 4th days	Cure
13	W	2500 r	8 hr. on 7th, 9th, 11th and 20th days	Recurrence
14	W	3000 r	8 hr. on 5th day	Death on 16th day. No tumor discoverable in local ulcer, but metastasis in groin
15	W	3000 r on 5th day	6 hr. on 1st and 5th days. 9 hr. on 11th day	Death on 22nd day. Small remnant of tumor alive, also metastases
16	W	3000 r	9 hr. on 5th day	Complete local cure, but metastases fatal after 33 days
17	W	3000 r	4 hr. 1st day; 8 hr. on 4th day	Cure
18	W	3500 r	5 hr. on 1st day	Severe vesication. Cure of original tumor; death in 26 days from metastases

* C = carcinoma, S = sarcoma, W = Walker tumor.

irradiation were tried without promising results. In addition to the lack of cures, the high mortality discouraged a continuance along this line.

9. IRRADIATION OF VISCERAL TUMORS

As the tumor-killing effect of local asphyxia is exerted through a reaction in the surrounding tissues, this effect was found

TABLE VI

SPLENIC TUMORS TREATED WITH ROENTGEN IRRADIATION AND LIGATION

No.	Type of Tumor*	Dosage (roentgens)	Ligation	Results
1	W	400	¾ hr. on 2nd and 9th days	Periphery of tumor alive
2	W	500	2 hr. on 2nd day	Death 8th day. Cavity in spleen; no sign of tumor tissue
3	W	2000	1 hr. 1st day	Tumor survived
4	W	2500	1 hr. 1st day	Original tumor killed. Spleen normal appearance. Death from pulmonary metastases
5	W	2500	2 hr. 1st day	Permanent cure. Spleen normal
6	C	2500	2 hr. 1st day	Permanent cure. Spleen normal
7	W	3000	1 hr. 1st day	Death 1 week. Tumor totally necrotic; spleen atrophied
8	W	1000 on 1st and 12th days, 1500 r 22nd day	3 hr. on 26th day	Death 33rd day. Spleen normal, tumor only partly necrotic
9	S	400	1 hr. 1st day	Death 5th day. Probably total necrosis of tumor
10	S	500 1st day, 1000 4th day	1½ hr. 1st and 4th days	Death 7th day. Possibly complete necrosis of tumor
11	S	500 1st day, 1500 4th day	1 hr. 1st and 4th days	Death 7th day. Possibly complete necrosis of tumor
12	S	2500	1 hr. loose, 1 hr. tight ligation, 8th day	Death 14th day. No living tumor discoverable
13	S	3000	2 hr. 8th day	Permanent cure
14	S	3500	1 hr. loose, 1 hr. tight ligation, 6th day	Death 14th day. Small remnant of tumor alive
15	S	3500	1 hr. 2nd day, 2 hr. 9th day	Death 27th day. Spleen slightly atrophic, small remnant of tumor alive

* C = carcinoma, S = sarcoma, W = Walker tumor.

to vary with the location of the tumor in different organs.[8] A similar comparison was therefore made with roentgen rays.

A series of 7 Walker tumors (4 testis, 2 spleen, 1 kidney) were given single treatments with 1,000 to 2,500 r of hard rays. The testes were treated *in situ* and the other organs were drawn out through incisions while the body was shielded. The organs, especially the testes, underwent extensive atrophy but the tumors survived. One testicular tumor was cured by 1,000 r followed after a week with 2,500 r, and the testis was completely atrophied.

A similar series of 11 tumors were given doses of soft rays from 1,500 to 3,500 r, with no result beyond partial necrosis or recession. In 3 of these instances, repetitions of the treatment produced necrosis of all visible tumor tissue but the animals died in six to fifteen days, so that final judgment of the result was impossible.

These results indicate that tumors are not more sensitive to roentgen radiation by reason of location in an organ which is more sensitive to the rays than the normal leg tissues.

10. Irradiation and Ligation of Visceral Tumors

The combined treatment was tried on several series of tumors, in the attempt to increase the efficiency or reduce the danger in comparison with ligation alone.[8] All irradiations of the 15 splenic tumors shown in Table v were given on the first experimental day, except as otherwise stated. Large, well established tumors in this location never recede spontaneously and are hopeless under any ordinary treatment. Therefore it is remarkable that, along with a high mortality, there were a number of sloughs of all visible tumor tissue and 3 permanent cures with survival.

A series of 23 tumors of the kidney gave an opposite result, in that there was only one cure (with 3,000 r and one hour ligation), and otherwise the large tumors merely sloughed in the center and continued to grow at the periphery. The normal tissue underwent atrophy, suffering greater damage than the tumor. It appeared theoretically interesting that inferior curative results were thus obtained with tumors located in an organ which is far more sensitive to roentgen radiation than the spleen.

The combined treatment of sarcomas in another radiosensitive organ, namely the testis, yielded 5 cures among 12 animals. The minimum treatment accomplishing this result was 500 r and one hour congestion plus one hour tight ligation, all repeated on the third day. Here also the testis atrophied completely. Therefore the attempt to find a method which would kill the tumor and spare the testis failed.

Conclusions

1. It was established that the tolerance of the normal tissues of the rat's leg for roentgen rays (*a*) is much higher than that of human tissues, (*b*) is apparently much higher for soft than for hard rays, and (*c*) is reduced by the local asphyxia resulting from ligation.

2. Established tumors in the legs are cured to a higher degree by a combination of irradiation and local asphyxia than by either of these measures alone. A point of theoretical interest is that asphyxia, which thus augments the effect of roentgen radiation, influences tumors through a reaction in the normal tissues rather than by direct destruction of tumor cells.

3. The effects of combined irradiation and local asphyxia are indistinguishable, whether the two are applied simultaneously or in sequence. Any expectation of a specially powerful action through accumulation of radiochemical substances during several hours of absence of circulation is thus disappointed. Also, the effects of both asphyxia and irradiation are persistent to the extent that an influence is demonstrable when either treatment is administered several days in advance of the other.

4. Attempts were made to improve the efficiency and selectivity of the treatment, as follows: (*a*) Fractionation of the roentgen-ray dosage appeared much less promising than in man, presumably because of the far more rapid growth of the rat tumors. (*b*) Intense venous congestion without arterial stasis increased the curative action of roentgen rays. (*c*) Combinations of local asphyxia, irradiation and fever were abandoned because of poor curative results in proportion to the high mortality.

5. Combined ligation and irradiation yielded a significant number of cures of tumors of the spleen and testis but not of the kidney. Therefore, though the cura-

bility of the same type of tumor may vary in different locations, it does not run parallel with the radiosensitiveness of the organ in which it is embedded.

In general summary, there was no attempt to settle questions of detail such as the optimum conditions for practical results, but the most important theoretical contribution appears to lie in the possibility of converting a radioresistant tumor into a radiosensitive one by means of a reaction excited in the surrounding tissues.

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THE EFFECT OF HEAVY FILTRATION ON SKIN TOLERANCE AND DEPTH DOSE

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THE optimum filtration for 200 kv. roentgen rays designed to give the maximum depth dose with the least skin effect has been a subject of some controversy. It has become a common practice to employ filters of 2 mm. of copper or the equivalent in a combination of tin and copper (Thoraeus filter) on the basis that the shorter wave lengths result in a greater skin tolerance and larger depth dose. The increase of filtration above 0.75 to 1 mm. of copper greatly decreases the intensity of radiation at 200 kv. and thus the problem of heavy filtration becomes of economic importance, particularly in clinics which serve a large number of patients with limited equipment. It, therefore, has seemed to us advisable to investigate heavily filtered 200 kv. roentgen rays from the standpoint of intensity, depth dose, and skin tolerance. Certain comparative data have also been obtained at 400 and 1,000 kv.

The small thimble ionization chamber may be subject to certain inaccuracies, but it is the commonly accepted means of comparing roentgen intensities. Such a chamber of standard make was employed in our experiments. Although the water phantom has been used for many years in making depth dose measurements, it has been found that several solid media will serve as well and can be more easily handled. Glasser uses a block of purple heart wood, and a pressdwood phantom has been suggested by Quimby. Pressdwood is a wall board made in several grades which vary in density. For our purpose, a sample which barely floated in water was chosen. A sheet of this board was cut into small sections 25 cm. square which were glued one above the other to make a cube 25 cm. on a side. Holes were then drilled in the block at various distances from the surface to accommodate the ionization chamber.

Several roentgen machines of various makes and ages were checked with this phantom. The units were operated at 200 kv., 0.5 mm. copper filter (plus the wall thickness of the tube which may be estimated as equivalent to an additional 0.25 mm. of copper), 10 by 10 cm. portal of entry. Discrepancies in the 10 cm. depth dose ranging from 32 to 37 per cent were noted among these machines. The newest of the units gave the highest depth dose and was selected for further experiment.

In order to check the accuracy of the pressdwood phantom, comparative measurements were made on several women under routine treatment for carcinoma of the cervix. The ionization chamber was covered by a rubber sheath, inserted into the vagina, and held in constant relationship to the surface of the pelvis by a special clamp. The depth dose is recorded on one of these subjects, a somewhat obese woman who measured exactly 10 cm. from the anterior surface of the pelvis to the ionization chamber. (In the average female pelvis the anteroposterior distance to the ionization chamber was found to be 8 cm., and the posteroanterior distance 12 cm.) For further comparison, 10 cm. depth measurements were made in a paraffin phantom. The operating factors were 200 kv., 50 cm. distance, 100 sq. cm. field, filtration either 0.5 or 2 mm. of copper. The results are shown in Table 1.

One notes that the absorption of radiation in the pressdwood phantom closely approximates that in the female pelvis; the depth dose in the paraffin phantom runs about 5 per cent higher. It will also be observed that the increase of filtration from 0.5 to 2 mm. of copper results in a 2 per cent increase in the 10 cm. depth dose. Water phantom measurements made by Quimby and Marinelli have also shown a 2 per cent difference. Further measurements

using the same pressdwood phantom have been made on roentgen machines operated at 400 kv. constant potential and 1,000,000 volts constant potential. The determinations of the 10 cm. depth dose with the units operating at 50 cm. distance with a 100 sq. cm. portal of entry are recorded in Table II.

Table I

	Female Pelvis	Pressdwood Phantom	Paraffin Phantom
Surface dose	100%	100%	100%
10 cm. depth dose with 0.5 mm. copper filter	38%	37%	43%
10 cm. depth dose with 2 mm. copper filter	40%	39%	45%

Table II

	200 kv.	400 kv.	1,000 kv.
Surface	100%	100%	100%
10 cm. depth dose	37%	39%	49%

The depth dose of 39 per cent on the 400 kv. unit checks well with Glasser's figures. It will be observed that at 1,000,000 volts there is an increase of 10 per cent. This increase becomes greater if the focal skin distance is lengthened.

Although the gain of 2 per cent in depth dose would not seem to warrant the increased expenditure of energy associated with the use of a 2 mm. copper filter at 200 kv., it was felt that any appreciable increase in skin tolerance might justify the use of the harder radiation. Therefore, certain clinical investigations on skin reactions were carried out:

The roentgen apparatus was operated at 200 kv., 20 ma., with a 2 mm. copper filter, and an ionization measurement was made at 50 cm. distance. An output of 15.5 r per minute was obtained. The filtration was then reduced to 0.5 mm. of copper and the current was lowered until the ionization intensity was the same as that measured with the 2 mm. copper setting. A decrease in the current from 20 ma. to 6.25 ma. (approximately one-third) was found necessary. These intensity measurements were made free in air since the difference in back-scatter between the 2 mm. and 0.5 mm. copper settings was found to be negligible.

A group of 10 patients was selected for study, the criteria for choice being as follows: The patient should have a hopeless prognosis so that any permanent skin change would not be troublesome, yet he must live long enough for suitable skin studies (at least one month). He must be intelligent and sufficiently free of pain and in good enough general condition to cooperate. Some of the treatments necessitated the maintaining of a fixed position without motion for an hour. The patient must have had no previous irradiation near the site to be studied.

In 5 cases corresponding areas were chosen for irradiation on the anterolateral aspect of the right and left thigh 6 inches above the knee. This field was irradiated obliquely to spare the structures in Hunter's canal. It was chosen to avoid irradiation of any viscus, and it was possible to treat these patients without a single case developing roentgen sickness. A 6 by 8 cm. portal of entry was employed, and during irradiation the opposite thigh was shielded with several layers of lead rubber. A dose of 800 r was administered continuously in one sitting to each thigh. The 0.5 mm. copper setting was used on one thigh and the 2 mm. copper setting was used on the corresponding area on the opposite thigh. The time necessary for the administration of each dose was fifty-two minutes. There was no interval between the exposures other than the time necessary to change the filters and shift the fields.

Our previous experience had shown us that a dose of 800 r, using a 0.5 mm. copper filter and a 6 by 8 cm. portal of entry, would produce a faint but definite ery-

thema in all cases. In other words, this dose is slightly above the so-called "threshold erythema."

The records on the 5 cases thus irradiated follow:

CASE I (No. 11776). Male, aged twenty-five. Inoperable carcinoma of the rectum with multiple peritoneal implants and a colostomy. The patient had completed a series of high voltage roentgen treatments directed to the rectum two weeks previously. Following treatment to the thighs, a faint blush became apparent in seventy-two hours. A definite redness developed in six days. The reaction was at its height by the tenth day and then gradually faded with the development of moderate tanning. The patient died seven months later. Slight pigmentation was still present which was equal on both sides. No difference whatsoever was noted in the reaction on the thighs as regards time of onset, time of attainment of peak of reaction, intensity, regression, degree of tanning, etc.

CASE II (No. 12043). Male, aged forty-six. Exploratory laparotomy four months before. Inoperable carcinoma of the stomach with peritoneal and hepatic metastases. No radiation therapy. Results identical to those described in first case. Patient died one month after therapy.

CASE III (No. 12017). Male, aged forty-nine. Exploratory laparotomy one week before. Inoperable carcinoma of the stomach with liver infiltration. Results identical to those described in first case. Patient died three months later.

CASE IV (No. 11860). Female, aged thirty-five. Scirrhous lymphoblastoma involving cervical, mediastinal, abdominal, and inguinal lymph nodes. Completed 900 r high voltage roentgen therapy to each side of the neck, mediastinum, supraclavicular areas, one week before. Following irradiation to the thighs, a faint redness appeared in about forty-eight hours which was identical on both sides (one day sooner than in the male cases). There was definite tanning by the eighth day. The reaction progressed to fine desquamation. The patient received subsequent roentgen therapy to the groins, abdomen, etc. Died five months later. Pigmentation was present and equal on both thighs.

CASE V (No. 11792). Female, aged fifty-three. Recurrent carcinoma of the left breast. Radical mastectomy done two months before. Invasion of the chest wall and marked axillary involvement. Irradiation of the thighs gave similar results to those described in Case IV. Patient still alive ten months later. Persistent tanning equal on both sides.

Although these observations indicate that there was no difference in the reaction to the skin to a single mild erythema dose, it was felt that the skin tolerance might differ for the two filters when heavier doses were applied. Consequently a group of cases was selected which were about to undergo bilateral radiation therapy. These patients received treatment on one side with the 2 mm. copper setting and on the other side with the 0.5 mm. copper setting. The results were as follows:

CASE VI (No. 12327). Male, aged forty-eight. Inoperable carcinoma of the rectum. Metastases in the liver. The patient received 2,000 r to each of four pelvic portals, 100 sq. cm., directed toward the rectum. Daily doses of 400 r were administered. The 2 mm. copper filter was used on the right side of the body and the 0.5 mm. copper filter on the left. The fields were widely spaced to avoid overlapping. The right anterior field (2 mm. of copper) was treated first and showed the earliest reaction, which was more intense than on the left. The left posterior field (0.5 mm. of copper) was treated before the right posterior, and showed an earlier reaction. Some diarrhea and nausea resulted during the last week of the series, but the roentgen sickness was in no way influenced by the type of filtration. No difference was noted in the reaction on both sides if the time of onset of therapy was taken into consideration. The patient was seen one month later, at which time there was marked tanning of all four portals.

CASE VII (No. 11966). Male, aged sixty-three. Recurrent carcinoma of the bladder. Partial cystectomy seven months before. Permanent cystostomy. The patient received a total of 1,200 r directed toward the bladder through four pelvic portals of 100 sq. cm., two anterior oblique and two posterior oblique; 400 r per day was administered. A mild erythema developed over all fields. The patient died two

months later, at which time there was slight persistent tanning. No difference was noted in the reaction of the two sides considering the time of onset of the therapy.

Case viii (No. 12357). Male, aged fifty-three. Carcinoma of the tongue, involving floor of mouth. Bilateral cervical gland metastases. This patient received 600 r to each side of the neck directed through portals of 100 sq. cm.; 400 r a day was given using 0.5 mm. copper filter on one side and 2 mm. copper on the opposite side. No difference was noted in the skin reactions. There was excellent regression of the disease. The patient was seen five months later at which time both sides of the neck were equally tanned.

In the last 2 cases one might raise the objection that the results were vitiated by back-scattering from adjacent fields. Therefore, 2 more cases were irradiated as follows:

Case ix (No. 12293). Female, aged twenty-nine. Carcinoma of the left breast. Extensive bone, pulmonary and lymph node metastases. The patient had fairly symmetrical metastatic areas in the heads of both humeri, therefore the upper arms were treated in lieu of the thighs. A total of 1,200 r was given to each arm in two days (600 r to two areas each day). The 0.5 mm. copper filter was used on one side and the 2 mm. copper filter on the opposite side. Very little reaction developed, and two weeks later this dose was repeated. The reaction which followed was identical on both sides.

Case x (No. 9660). Male, aged forty-nine. Recurrent carcinoma of the buccal mucosa. Involvement of the floor of the mouth and tongue. Metastases to the submaxillary and jugular nodes. Received roentgen therapy to both sides of the face and neck one year before. This patient was given 2,400 r to each thigh at the rate of 300 r per day (6 by 8 cm. portals). The 0.5 mm. copper filter was used on one side and the 2 mm. copper filter on the opposite side. No difference was noted in the immediate reactions or in the degree of tanning which was observed one month later.

CONCLUSIONS

Our observations lead us to conclude that, although the depth dose is slightly higher, the skin tolerance is so little altered by increasing filtration from 0.5 mm. of copper to 2 mm. of copper that the difference cannot be detected clinically. We are in agreement with Quimby and others that an increase in filtration sufficient to materially affect the quality of radiation supplied at 200 kv. prolongs the treatment time beyond practical limits. We do not mean to disparage the attempt to obtain shorter wave lengths. Although there is no great difference between the depth dose measurements made at 400 kv. and 200 kv., it has been our observation that at 400 kv. the skin tolerance is increased about 25 to 30 per cent, and at 1,000,000 volts constant potential the skin tolerance is practically double as compared with 200 kv. radiation. This is in accord with the work of Leucutia and Corrigan.

It is beyond the scope of this paper to discuss the specific biological effectiveness of heavily filtered roentgen rays on malignant tissue. The clinical observations of those radiologists who have for years employed heavy filters with 200 kv. apparatus and have claimed better results are not to be discounted. We are aware of the fact that radiation therapy should not be administered according to a physical formula and that biological effects and physical measurements do not necessarily run parallel. The close cooperation of the physicist and clinician is necessary to obtain the best results.*

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* The 200 kv. skin tolerance tests were carried out at the Pondville Hospital at Norfolk (Massachusetts Department of Public Health). Physical measurements on roentgen apparatus were made at the Collis P. Huntington Memorial Hospital, Harvard University; the Massachusetts General Hospital; the Palmer Memorial Hospital.

A METHOD OF OBTAINING GREATER RATIO OF DEEP TO SURFACE DOSAGE*

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THE principle, hereinafter described, which will increase the percentage of radiation measured at the center of the body, as compared with that at the surface, was suggested by Dr. Wheeler P. Davey, Research Professor of Physics and Chemistry, at Pennsylvania State College. Flax[1] has reported the use of a similar principle in a different manner.

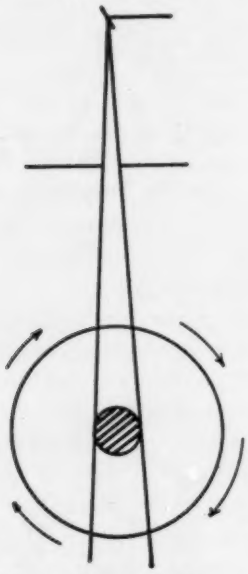

FIG. 1. Diagram of setup.

The method consists of rotating the patient during the treatment, in the upright position, with the axis of rotation perpendicular to the central ray and parallel to the long axis of the body. The beam is directed horizontally. This will distribute the surface radiation evenly over the circumference of the body. Any point on the surface receives direct radiation only as it passes across the beam between the center of rotation and the target. A small amount of radiation is received as the point passes through the exit beam, and a very small amount of scattered radiation between these two places.

At the same time a volume surrounding the axis of rotation is receiving radiation continuously. The amount so radiated depends upon the size of the port used. Figure 1 is a diagram of such a setup, assuming a cylindrical body is to be irradiated.

FIG. 2. Photograph of phantom.

From geometrical considerations, it seems likely that certain things should be true of such an arrangement. The narrower the portal and the greater the skin-target distance, the greater should be the percentage of radiation measured at the center. Using an assumed absorption coefficient, and assuming a cylindrical body

* From the Department of Roentgenology, G. F. Geisinger Memorial Hospital, Danville, Pa. Read at the Thirty-ninth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 20–23, 1938.

to be irradiated, values for these conditions can be calculated which show that it should be possible to put considerably more radiation in the center than is applied to any one point on the surface.

To test the accuracy of these assumptions, measurements were made on a phantom (Fig. 2). The phantom is made of Masonite wood, shaped like an idealized human female pelvis, the contour being taken from the cross section charts of Desjardins. The center of the phantom is made of lamina placed vertically so that the ionization chamber is perpendicular to the central ray throughout the rotation. For surface measurements the surface is hollowed out so the ionization chamber is half submerged. The phantom measures 39.5 cm. in its transverse diameter. The anteroposterior diameter is 29.0 cm., and the distance from the center of the front to the most posterior point is 30.5 cm. (Fig. 3). This is slightly larger than the average measurements for the female pelvis.

The machine used was an air-cooled, mechanically rectified apparatus. The

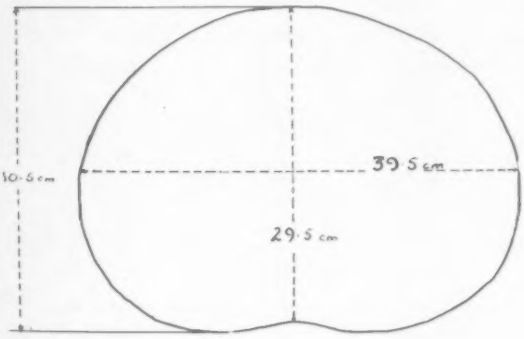

Fig. 3. Dimensions of phantom.

tube, an air-cooled type, was enclosed in a large lead drum. The only inherent filtration was the glass of the tube.

The distance from the target to the anterior surface of the phantom was 70 cm.

In each instance a portal 4.1 by 20.6 cm. was used. The object was to use as narrow a portal as possible. A portal of 2 cm. width was tried, but the setting of the ionization chamber was too critical for accurate measurement.

The turntable turned steadily at the rate of one revolution in fifty-five seconds.

Measurements were made with a Victoreen condenser r-meter, which was cali-

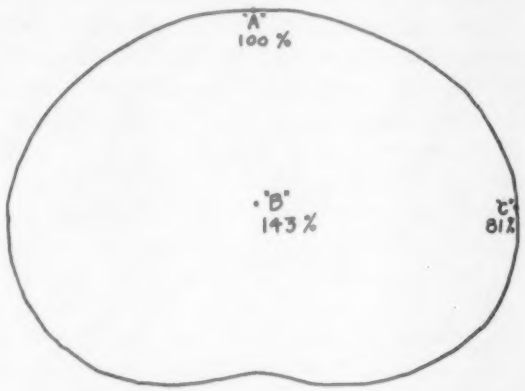

Fig. 4. Percentage of intensity with 0.5 mm. Cu at surface and center, rotating.

brated immediately before the measurements were made.

The machine was operated at 200 kv. (peak), and 10 ma. The half-value layer of 0.5 mm. copper is 0.8 mm.; and for 2 mm. copper is 1.5 mm.

Table I

0.5 mm. copper + 1.0 mm. aluminum

	Per cent
Middle of anterior surface, not rotating.....	100.0
15 cm. below surface in midline, not rotating	16.2
Middle of anterior surface, rotating.....	100.0
15 cm. below surface in midline, rotating....	143.1
Middle of lateral surface, rotating.....	81.0

Table I gives a summary of measurements at 0.5 mm. of copper and 1.0 mm. aluminum; Table II gives a summary of the measurements at 2.0 mm. copper plus 1.0 mm. aluminum. These measurements are the averages of at least three, and usually more readings, all of which are within 2 per cent of each other. Surface measurements are all made with back-scatter.

To interpret these figures in terms of dosage, if 1,000 r is given on the surface, with the phantom rotating (Fig. 4), a point 15 cm. below the anterior surface in

the midline, or at the middle of the phantom, receives 1,431 r. Or, if you put 1,000 r into the point 15 cm. below, you will only have put 699 r on the point of maximum intensity on the surface (Fig. 5).

The point on the lateral surface of the phantom farthest from the center was measured, as it was thought that, as this point came closest to the tube during the rotation, it might be the point of maximum intensity on the surface. This proved not to be true. This is due to the fact, that though it does come closer to the tube, it is moving slightly faster, and the beam is a

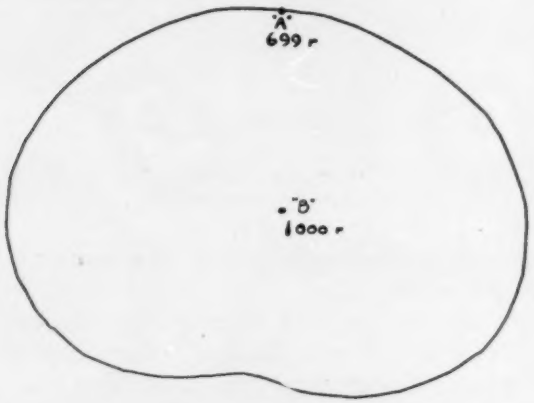

FIG. 5. Dosage at surface and center, 0.5 mm. Cu plus 1.0 mm. Al.

trifle narrower. Furthermore, there is a longer time during which the greatest width of the phantom acts as a filter, while this point is away from the tube.

TABLE II

2.0 MM. COPPER + 1.0 MM. ALUMINUM

	Per cent
Middle of anterior surface, not rotating....	100.0
15 cm. below surface in midline, not rotating	17.5
Middle of anterior surface, rotating.....	100.0
15 cm. below surface in midline, rotating....	167.0
Middle of lateral surface, rotating.....	85.8

These figures are materially better than the ones at 0.5 mm. of copper. In terms of dosage, 1,000 r on the surface will give 1,670 r to a point 15 cm. below the surface, or at the middle of the phantom. On giving 1,000 r to the point at the middle you only apply 598 r to the surface (Fig. 6).

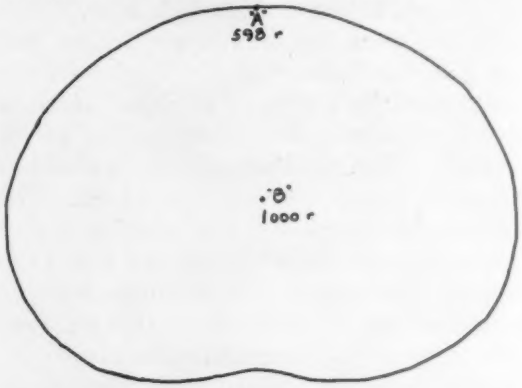

FIG. 6. Dosage at surface and center, 2.0 mm. Cu plus 1.0 mm. Al.

Figure 7 gives the curve of intensity along the transverse axis of the phantom measured during rotation. There is an area about the center of even distribution. On each side of this the intensity falls away rapidly, to a plateau which extends close to the surface. The rapidly falling portion is at the edge of the beam. The intensity was not measured in the portion of these curves shown by the dotted line. The points on the surface, however, were measured.

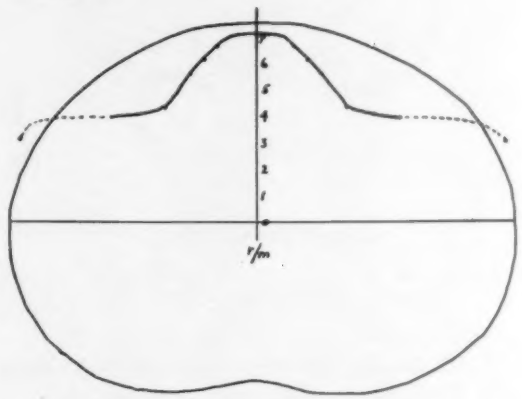

FIG. 7. Distribution of intensity, transverse diameter.

Figure 8 shows the intensity distribution along the middle anteroposterior axis. Due to the fact that the beam is much longer than it is wide, the flat portion of

the curve on either side of the center is longer than in the transverse diameter, and the drop produced at the edge of the beam is decreased. It may be that the use of a wider beam will be more advantageous, as it will make the flat tops of the curves on the two diameters more nearly equal. Further investigations are being made on this question.

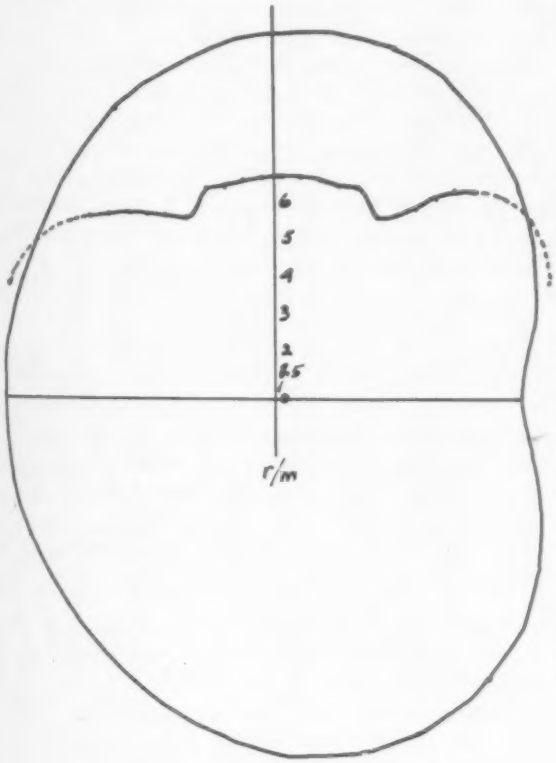

Fig. 8. Distribution of intensity, anteroposterior diameter.

The asymmetry of the posterior half of the curve in the anteroposterior diameter is interesting. It is due to the flatter and more irregular shape of the posterior surface of the phantom.

It is frankly admitted that this study does not cover all the questions to be answered before applying this method to a patient. Some of these questions, which are under investigation are: (1) the effect of portal size, (2) the selection of the most efficient portal for various sized patients, (3) the distribution of intensity along various diameters, (4) the distribution of radiation with the phantom placed eccentrically, (5) the distribution in other, more irregular cross sections of the body, and (6) determination of the most efficient distance.

This method of treatment appears to offer possibilities of improving the depth dose obtainable, and of shortening the treatment time. It can be used with the shockproof apparatus in general use today, with the addition of a simple turntable.

SUMMARY AND CONCLUSIONS

A method of irradiation is suggested whereby it appears to be possible to increase considerably the amount of radiation given to a point at the center of the body, as compared with the amount given to any point on the surface.

Reports of preliminary measurements on a phantom are given which indicate that this can be done.

Curves showing intensity distribution along two diameters, at right angles, in a pelvis-shaped phantom are given.

Further aspects for investigation are outlined.

I wish to extend my thanks to Mr. Walter S. Lusby, of Harrisburg, Pa., for his willing assistance; to Mr. C. S. Eason, and the Westinghouse X-Ray Corporation for the loan of some equipment; and to Mr. J. L. Weatherwax for his patient advice.

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DISCUSSION

Dr. Otto Glasser, Cleveland, Ohio. This interesting paper by Dr. Hawley shows again the progress which has been made in the construction of apparatus for radiation therapy. It is only by use of modern equipment that it is now possible to obtain satisfactory results by employing an idea which in itself is rather old.

I remember that when I joined Friedrich and Krönig in 1916, one of the first pieces of apparatus which I saw and which made a very great impression on me was a large, black box with a long metal arm at the end of which

was suspended a roentgen tube. Friedrich demonstrated that piece of apparatus and explained that it was a tube which swung back and forth continuously over the patient while he was being treated. However, the first experiments made with this apparatus were not very satisfactory because the high tension protection was unsatisfactory; therefore the entire apparatus from the standpoint of treatment was dangerous. So far as I know, its use was discontinued after the first experiments.

Various other methods have been tried and I mention here, for instance, a tube of the type which Loebell suggested and which has different portals. Many attempts have also been made to rotate the patient or the roentgen tube. As mentioned previously, it is only by the development of high protection, shock-proof tubes, which insure against the effects of radiation and high tension that studies such as Dr. Hawley presented this afternoon are possible.

It is a strange coincidence in the history of science that similar investigations are often made simultaneously by quite distant workers. Last year Dessauer of Constantinople published his method of turning the patient while being treated and at about the same time another such study was published by Mesnil de Rochemont of Giessen. These two investigations were made entirely independent of Dr. Hawley's study. In their studies the patient sat on a chair which revolved slowly. Dr. Hawley's patient turns around once in fifty-five seconds while Dessauer's patient turns around once during the time of treatment. All three investigators have published measurements on phantoms. Dessauer has used a phantom representing the upper lung area and also one representing the pelvic area. All the investigators feel that there is a definite improvement in the depth dosage as compared with the standard treatment technique. It would take too long, however, to go into detail about this improvement; suffice it to say that, generally speaking, there is an increase of between 20 and 25 per cent in the depth doses at the site of the tumor, and I feel that this is sufficient reason to investigate this matter further.

DR. G. FAILLA, New York City. I have enjoyed listening to Dr. Hawley's paper and it seems to me that if the aim is to increase the depth dose, this is probably the simplest and surest way in which to do it.

The thing that passed through my mind while I was listening to the paper was whether it is desirable or advantageous to irradiate a large mass of tissue as uniformly as this method would permit. In other words, the patient will stand a certain amount of radiation and ultimately the limit as to the depth dose one can deliver depends on how much radiation the patient can stand, not only on the skin but in the internal structures.

In the treatment of a leg with the tumor at the center one may feel that this type of treatment is indicated because the total volume of tissue intensely irradiated is not so large in comparison with the size of the patient. It may be that the human system (not considering the leg) can stand that much radiation over that volume of tissue, but when it comes to the chest or the pelvis, I doubt very much that one can use this method and ultimately obtain the advantage that is apparent on paper.

It may be possible that with a limited number of beams, one can actually deliver more to the tumor because of the fact that the patient can stand it better than by this method. It will be very interesting to see how the clinical part of the work will turn out. I think that is really the most important part, and I would suggest that a little caution be exercised in the treatment of patients by this method because of the large volume of tissue which is irradiated with rather uniform intensity throughout.

DR. GEORGE E. PFAHLER, Philadelphia. I think we are indebted to Dr. Hawley for calling our attention again to the importance of the cross-fire method, which, of course, is very old but needs to be repeated from time to time and needs to be applied skillfully and continuously always.

Dr. Hawley has made these measurements carefully to convince us of the value of cross-fire. We have, however, by his methods certain clinical and practical difficulties in which we are involved. In the first place, I have yet to see a single instance of carcinoma or any malignant tumor that is so obliging as to occur exactly in the center of the body or in the center of a circle or circumference, just as he has outlined. I have never seen one. The nearest approach to this central localization of a tumor is a carcinoma of the uterus. Nearly all deep therapy or cross-firing and planning a treatment idealistically and by the physicist assumes that the tumor is located in a central area. This does not occur in practical oncology. Even in the case of car-

cinoma of the uterus, there are practically always infiltrations into the left side of the pelvis, or perhaps in the right or extending upward along the ureter, all of which must be taken into account, and the cross-fire method must be adapted according to the location of the disease.

In these days with higher and higher voltage and higher filtration, we are less concerned with the effect obtained on the skin than with the effects on the normal organs between the skin and the diseased portion. One of these tissues that is often forgotten is the subcutaneous fat. We all know that this subcutaneous fat contains relatively few blood vessels, and therefore necrosis or fibrosis is apt to take place in this tissue even when the skin may be in good condition and there may have been no damage in the skin. Even the condition of the skin must be considered but it is of less importance than the deeper tissues.

I think the cross-fire method must be applied with particular thought as to the tissue that is being irradiated in these beams. On this account, I think we can never set up a case on a purely mechanical basis. In other words, I do not believe that we can treat any two uterine cases exactly the same. We must adapt the beams according to the principles of irradiation and with particular reference to the extent and location of the malignant disease that is involved. Furthermore, we must try to limit our field of irradiation to as small a space as possible, so long as we are not missing some of the diseased tissue.

Dr. Hawley (closing). I want to thank Dr. Glasser, Dr. Failla and Dr. Pfahler for this discussion. The point which Dr. Pfahler brought up, as to whether or not it is wise to irradiate a large amount of tissue, I am not prepared to answer because I do not know. The answer is partly, in this method of treatment, linked up with the points which Dr. Pfahler brought up, which are extremely well taken.

There is, however, one aspect of this type of treatment which may make it more desirable than the other method, the old multiple portal method of cross-firing; that is, with the multiple portal method of cross-firing, the greatest amount of radiation is on the surface and in the intervening tissues between the surface and the tumor, whereas with a rotating method the distribution is turned around. The amount is greatest in the region of the tumor and lowest close to the surface, and the intervening tissue is receiving a little less radiation than it is with multiple portals.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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Twenty-fifth Annual Meeting: New York City, June 10–11, 1940.

EDITORIALS

CALCIFICATION OF THE COSTAL CARTILAGES

SINCE the earliest days of roentgenography it has been noted that calcification takes place in the costal cartilages in varying degrees and amount. It has long been known that when there is an orderly calcification of the costal cartilages it begins in the first ribs at the age of about twenty-seven and the subsequent ribs are involved as age advances, the calcification being completed about middle life. What brings about this calcification is not understood. Köhler was among the first to devote a great deal of attention to the matter and he concluded that "The whole subject deserves further attention," and "The whole theory of calcification of the costal cartilages is certainly very interesting and far from being explained."

King* has quite recently taken up the subject from an experimental point of view and he says that the previous attempts at providing an explanation of costal cartilage calcification have failed for two reasons, first, by attempting to relate the process to recognized diseases, and second, from a failure to examine material which shows that the currently accepted view of the form of the calcareous deposit is certainly wrong. From his study he draws the conclusion that cartilage calcification should be regarded as a physiological process unrelated to pathology, and of the nature of a vital response of the cartilaginous tissue to the strains and stresses imposed on it by the general bodily function.

From an anatomical consideration he calls attention to the fact that the costal cartilages from the first to the seventh ribs articulate with the sternum and the cartilages of the eighth, ninth and tenth ribs unite with one another anteriorly and fuse with the lower border of the cartilage of the seventh. The eleventh and twelfth ribs have no costal cartilages. The cartilage of the first rib differs from the others in that it is shorter and broader and is united by a very broad surface to the manubrium, and there is no joint between the first costal cartilage and the manubrium, in contradistinction to the other costal cartilages which have a very definite synovial joint with the sternum.

It is the first costal cartilage which shows calcification when it occurs in an orderly fashion, and in the early days of roentgenology of the chest, especially in those cases exhibiting tuberculosis, elaborate studies were made on the cartilage of the first rib in an attempt to show that early ossification was the reason for the apices being the site of infection, and great importance was attached to the angle which the first rib formed with the first dorsal vertebra as a sign of a predisposition to pulmonary tuberculosis. Of course this theory has long since been disproved.

King points out the complexity of the movement of the costal cartilages during respiration, as a result of which the costal cartilages are under great stress and strain. He also notes the incorrect views which have been held regarding the ossification of rib cartilage, quoting Cunningham and Quain as being in error in describing the decalcification as peripheral or perichondrial.

For a long time calcification of the costal cartilages was thought to be associated with certain disease processes and more recently Huyssen has attempted to show that the extent of the general calcification of the costal cartilages may be usefully employed as an index of the condition of the blood vessels as an indication of arte-

* King, J. B. Calcification of the costal cartilages. *Brit. J. Radiol.*, Jan., 1939, *12*, 2–12.

riosclerosis. In his studies post-mortem investigations were made of all the main arteries and valves of the heart and the findings were compared with the degree of calcification present in the rib cartilages. Huyssen, in an analysis of these studies, came to the conclusion that while certain wide variations existed there was some interrelationship of the two conditions and that the cartilage calcification might be taken as a guide to the state of the vessels. Commenting upon this observation, however, King notes that arteriosclerosis and costal cartilage calcification are both conditions found with increasing frequency at advancing age and that a certain coincidence is inevitable, and King admits that while little is known of the essential cause of vascular degeneration the condition is so fundamentally different from any type of ossification of skeletal connective tissue that a fundamental relationship would appear extremely unlikely.

The only systemic condition that appears to have some influence is that of long-standing malnutrition. Köhler pointed out the fact that those who suffered from chronic starvation showed the greatest degree of calcification of their costal cartilages, but some doubt might be cast upon this observation by the fact that apparently calcification of the costal cartilage occurs as frequently among the wealthy and well-to-do as among the poorer classes of the population.

King calls attention to the fact that in a consideration of the process by which cartilage may become either the seat of calcareous deposit or transformed into bone, it is necessary to consider the underlying physiological processes involved, and he refers to Reichert's studies regarding bone, cartilage and fibrous tissue, namely that these are essentially one, with a common mesodermal origin, and subject to the same laws of development and under certain conditions capable of replacing one another. King further points out that for tissue change to come about in the adult body a stimulation of some kind is required unless the process be entirely one of deterioration and atrophy with loss of function, and that certainly calcification of the costal cartilage is a process far from being one of atrophy but is one of active response exhibiting extensive vascularization, canalization and true ossification. From his studies and observations he is led to believe that calcification of the costal cartilage is a misnomer, that ossification is the correct term, and that the ossification is a response to body needs. The stimulus affecting the rib cartilage is, in his opinion, largely one of stresses and strains falling upon the anterior thorax as a result of man's assumption of the upright posture, and there is an inherent instability in the thoracic cage in man as a result of assuming the upright posture, but in addition to this every contraction of muscle attached to rib cartilage, namely during respiration, constitutes a minimal trauma and can be viewed as a stimulus to physiological change in the direction of increased strength and the only form in which such change may take place in a beneficent manner is toward ossification.

Another factor which King emphasizes as a possible cause of ossification of the cartilage is some disturbance in the local blood supply to the cartilage and during every respiratory movement there is minor trauma to the costal cartilage, however infinitesimal, resulting in a reactionary hyperemia with some vasodilatation of the central blood vessels in the rib cartilage. He would explain part of the ossification at least on this increased vascularity which makes costal cartilage calcification possible. He suggests that it is not alone the vascular changes in themselves but some influence of a dietary and biochemical nature, and calls attention to the possibility that there may be a deficiency, possibly transitory, of vitamin D or an excess of fat which interferes with calcium metabolism, and while these changes may be minimal and asymptomatic, calcium balance dis-

turbances of dietetic origin do undoubtedly play a part in the varying degrees of cartilage ossification.

What part the thyroid, parathyroids, and the pituitary play in the ossification of the costal cartilage is not clear.

In order to arrive at some comparison King made a chemical analysis of ossification of a rib and compared this with analysis of a normal bone and he found from these comparative studies striking evidence that the type of calcification of the cartilage conforms very closely with the chemical composition of true bone, the greatest disparity being in the proportion of magnesium, but he discounted this finding as analyses of normal bone vary greatly in their magnesium content. One of the most important points brought out in this comparative study was that the relation of phosphorus to calcium is for all practical purposes that of the normal skeleton.

King in his conclusions calls attention to the inadequacy of the studies thus far conducted on costal cartilage ossification and states that it warrants further study. The studies thus far conducted offer proof that the majority of the accepted views are erroneous and most of the accepted views appear to be statements which having been once said have been repeated without verification of the real histology of the condition. King's views are at variance with some observers in that he believes a knowledge of the whys and wherefores of the ossification of the costal cartilage is of practical application. He believes that if a proper understanding of this process could be achieved the findings of the presence or absence of calcification in the rib cartilage on roentgen examination might well be found to be grounds for a diagnosis of long-standing dietetic or endocrine disturbances. He considers the subject of sufficient importance to warrant the cooperation of histologists, physiologists, biochemists and roentgenologists toward a solution of what appears to be a simple problem of comparative non-importance but the solution of which might actually throw considerable light upon the formation of bone in the adult.

EXPLANATION FOR THE RIBBING SEEN IN WALLS OF DILATED CEREBRAL VENTRICLES

THOSE who have had occasion to examine ventriculograms and encephalograms have noted in cases of dilated cerebral ventricles that the smooth walls encountered in normal sized ventricles give way to irregular contours. These irregularities are composed of transverse, rib-like arches which project more deeply into the lumina of the cavities the greater the dilatation of the ventricles.

Dyke and Davidoff* have noted this appearance and they and others have noticed that some patients who exhibit large ventricles may show few and shallow projections into the ventricles. It has been demonstrated also that the bands of tissue which produce these arches are most pronounced in the roofs of the lateral ventricles and grow less prominent as they reach the side walls. In pneumo-encephalograms of cases of internal hydrocephalus of various degrees, these irregularities are frequently seen, being most marked in the roofs of the bodies of the lateral ventricles, less marked in the anterior and occipital horns, and entirely absent in the temporal horns. These irregularities give a scalloped appearance to the boundary of the ventricular gas shadows.

They have been considered of no practical pathological significance, consequently the factors producing these shadows had not been previously investigated until

* Dyke, C. G., and Davidoff, L. M. An explanation for the ribbing seen in the walls of dilated cerebral ventricles. *Yale J. Biol. & Med.*, May, 1939, *11*, 485.

the curiosity of Dyke and Davidoff was aroused sufficiently to make an investigation of the causative factors. They had occasion recently in a case of a child with advanced internal hydrocephalus showing this ribbing of the ventricles to examine the brain at autopsy and it was found on horizontal section of the preserved brain that the ridges were prominently displayed. It was noted that at the apex of each rib running longitudinally with it was a blood vessel and it seemed to them that the presence of these ridges could give rise to the ribbing which was observed during life and that the mode of projection of the ribbing of the ventricles depends probably upon the degree of elasticity or resistance to stretching of the white matter as compared to these properties of the blood vessels. The pressure within the ventricles produces a dilatation and thereby causes an elongation of the blood vessels up to the limits of their elasticity. When this point is reached the remainder of the ventricular wall continues to recede between the blood vessels except where the resistance of the blood vessels to further stretching protects the brain tissue adherent to them. In this way there results a series of vaulted arches; the free margins of each of these is formed by a blood vessel covered by ependymoma.

This explanation for the ribbing seen in the walls of cerebral ventricles, while not of pathological interest in itself, is of considerable anatomical importance.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. C. B. Peirce, Royal Victoria Hospital, Montreal. Canada. Annual Meeting: Boston, Mass., Sept. 30–Oct. 4, 1940.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Next Annual Meeting: New York City, June 12, 1940.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: New York City, June 10–14, 1940.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Atlanta-Biltmore Hotel, Atlanta, Ga., Dec. 11–15, 1939.

RADIOLOGICAL SECTION, BALTIMORE CITY MEDICAL SOCIETY
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets twice annually in May and September.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill. Next meeting Peoria, Ill., May 21–23, 1940.

RADIOLOGICAL SECTION, LOS ANGELES CO. MED. SOC.
Secretary, Dr. Wilbur Bailey, 2007 Wilshire Blvd., Los Angeles, Calif. Meets on second Wednesday of each month at County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. L. J. Taormina, 1093 Gates Ave., Brooklyn, N. Y. Meets monthly on first Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. C. J. Challenger, 3117 Logan Blvd. Meets second Thursday of each month October to May inclusive at the Hotel Sherman.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. H. A. Mahrer, 10515 Carnegie Ave. Meets at 6:30 P.M. at Mid-Day Club rooms on fourth Monday each month, October to April, inclusive.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. E. A. Schmidt, 4200 E. 9th Ave., Denver, Colo. Meets third Tuesday of each month.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

FLORIDA STATE RADIOLOGICAL SOCIETY
Secretary, Dr. J. N. Moore, 210 Professional Bldg., Ocala, Florida. Meetings in May and November.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. R. C. Pendergrass, Prather Clinic Bldg., Americus, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. E. P. Halley, Decatur and Macon County Hospital, Decatur, Ill. Meetings held quarterly, time and place designated by president.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. C. C. Taylor, 23 E. Ohio St., Indianapolis, Ind. Meeting held the second Sunday in May annually.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. J. C. Bell, 402 Heyburn Bldg., Louisville. Meets annually in Louisville on third Sunday afternoon in April.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. C. S. Davenport, St. Lawrence Hospital, Lansing. Three meetings a year, Fall, Winter, Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. I. I. Cowan, Mt. Sinai Hospital, Milwaukee, Wis. Meets monthly on first Friday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

NEBRASKA RADIOLOGICAL SOCIETY
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets first Wednesday of each month, at 6 P.M., at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. A. O. Hampton, Massachusetts General Hospital, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. W. J. Marquis, 198 Clinton Ave, Newark. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. R. D. Duckworth, 170 Maple Ave., White Plains, N. Y. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year—January, May, November.

PACIFIC ROENTGEN CLUB
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport, Pa. Annual meeting, June, 1940, exact time and place to be decided.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. B. R. Young, Temple University Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St

PITTSBURGH ROENTGEN SOCIETY
Secretary, Dr. H. W. Jacox, 4800 Friendship Ave., Meetings held second Wednesday each month, 4:30 P.M., October to June at various hospitals.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. S. C. Davidson, 277 Alexander St., Meets on second Thursday from October to May, inclusive, 8 P.M., Rochester Academy of Medicine Building.

ST. LOUIS SOCIETY OF RADIOLOGISTS
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of October, January, March and May, at a place designated by the president.

SAN FRANCISCO RADIOLOGICAL SOCIETY
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco. Meets monthly on first Monday at 7:45 P.M., alternately at Toland Hall and Lane Hall.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

South Carolina X-Ray Society
Secretary, Dr. Hillyer Rudisill, Jr., Roper Hospital, Charleston. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg. Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. H. C. Harrell, 517 Pine St., Texarkana, Texas.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00-5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. V. W. Archer, University Hospital, University, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday of each month at the College Club, Seattle.

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets monthly on third Thursday, from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine, 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. Barbara M. Key, 32 Welbeck St., London, W.1, England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to Nov. incl. for scientific discussion.

Canadian Association of Radiologists
Secretary, Dr. A. C. Singleton, Medical Arts Bldg., Toronto, 5, Ontario.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext., Halifax, N.S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7, Madrid, Spain. Meets monthly in Madrid.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel. Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during month of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, 11.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent Secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgensellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the fall.

Societa Italiana Radiologia Medica
Secretary, M. Ponzio, University of Turin, Prof. Turin

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly on first Monday at 8 o'clock.

Polish Society of Radiology
Secretary, Dr. Jan Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime:

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen.
Meets the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6:30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University. Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

THE BUSINESS SIDE OF RADIOLOGICAL PRACTICE*

A Bulletin for Fellows and Residents in Radiology in their Final Year of Post-Graduate Training

(*Continued from October*)

Going into Practice

If the radiologist decides to open a private office in an office building when he enters practice, his problem is a straightforward one. He rents a certain amount of space (including light, water, etc.) from the building, purchasing and installing certain necessary equipment. He selects a technician who will probably also act as secretary during the early years of his practice until his clientele permits him to increase his staff. He collects his fees from his patients and carries on his practice just as any other physician. For a few years his income is modest but it should gradually increase until his income is one which compares favorably with the income of other medical specialties. He will find that the cost of practicing his profession in a private office will vary from 40 to 60 per cent of the gross collections, depending upon the type of work he does and the part of the country in which he is located.

In addition to his office practice, the radiologist may seek a hospital appointment; or he may decide to accept a full-time hospital appointment. There are three general classifications of hospitals: Those occupied exclusively by non-pay patients, those occupied by a combination of non-pay and pay patients, and those occupied by pay patients alone. The first are exemplified by federal, state, and municipal hospitals, mental and tuberculosis institutions. Since no fees are collected from patients of these hospitals for medical services the problem of private practice of medicine does not arise. The majority of physicians appointed to hospitals of this type are appointed on a salary basis and it is reasonable and equitable for the radiologist accepting such an appointment to be on a similar basis.

The second group of hospitals consist of a variable number of pay patient rooms and non-paying patient rooms and wards. In this type of institution, the radiologist should be appointed as are his colleagues on the medical staff and should practice medicine as far as private patients are concerned just as do those colleagues. Since the hospital provides space or space and equipment it is necessary that the radiologist reimburse the hospital for the use of these facilities just as he would in his office building. This may be done in one of several ways. In many institutions the radiologist rents or leases the department, including its equipment, from the hospital, paying the latter a monthly rental. In others, the hospital is paid a unit cost for each case examined. The manner in which charity patients are handled in institutions of this type will vary according to the proportion of charity patients to pay patients. When the amount of pay work handled in the department will justify it, it is probably best for the radiologist to perform services for charity patients without charge, if this is the custom in other departments of the staff. Where the ratio of charity patients is high, however, it is frequently necessary for the radiologist to receive an honorarium from the hospital for the full time which he devotes to these patients.

In the third group of hospitals, those where all admissions are pay patients, the most ethical and efficient arrangement is one under which the radiologist leases the space or space and equipment and pays the hospital a monthly rental. The monthly rental will vary according to the size of the hospital and according to whether the hospital provides only space or space and equipment. In actual practice it varies all the way from $300 per month in a small hospital to as much as $3,000 per month in very large institutions. A rental which exceeds 40 or 50 per cent of the monthly gross income of the department is probably too high.

* Bulletin of the Inter-Society Committee for Radiology.

Fiscal Arrangements

There has been an unfortunate tendency for some hospitals to regard radiology as a part of hospital care and to look upon the radiologist as a technician employed by the hospital, filling an ancillary rôle in the practice of medicine. Some institutions have gone so far as to frankly demand a sizable net profit from the fees earned by physician-radiologists practicing in the hospital.[6] It is this tendency which is responsible for many of the current problems of radiology and which demands the concerted and unified attention of practicing radiologists.

Because of the extensive equipment necessary for the practice of radiology and because of the fact that the hospital frequently owns this equipment, there have developed certain methods for handling the financial transactions for hospital radiology which are different from the methods employed for other clinical specialties. Although radiologists in an increasing number of hospitals have precisely the same relationship with a hospitalized patient as with one in their own private office, charging and collecting their own fees and reimbursing the hospital for the use of the facilities provided, the great majority of hospital radiologists today practice on a percentage basis, sharing the gross receipts with the hospital. Many radiologists are paid a salary by the hospital. While the number who collect their own fees and reimburse the hospital is, as stated above, increasing each year, they are in the minority.

In a study recently completed by the Inter-Society Committee for Radiology, it was found that 36.4 per cent of radiologists working part or full time in one or more hospitals were employed by the hospital on a salary basis. This included, of course, governmental institutions, group clinics and other institutions where the entire medical staff was on a salary. Of the remainder, 47.3 per cent had a percentage agreement, based upon gross income in about 65 per cent of the cases and on the net income in the balance; 7.3 per cent were on a salary plus commission basis; 9 per cent were on a rental or lease basis under which they reimbursed the hospital for use of its facilities. Most of the remaining 7.3 per cent charged and collected their own fees, having no financial arrangement with the hospital. A total of 21 per cent were found to collect their own fees.

[6] See Appendix B of the "Manual of Desirable Standards," American College of Radiology, for the American Medical Association ruling on this point.

Ethical Considerations

For a complete discussion of fiscal matters pertaining to a hospital roentgen-ray department, the reader is referred to Section 10 of the "Manual for Desirable Standards of Hospital Radiological Departments" issued by the American College of Radiology. In considering a proposed hospital connection under any type of fiscal arrangement, the radiologist should never lose sight of two fundamental principles: It is difficult for good medicine to be practiced when a corporation renders the service through the medium of employed physicians, and no third party should be permitted to come between a doctor and his patient.

Failure to observe these principles will inevitably and ultimately react to the disadvantage of the patient, for whose benefit all principles of medicine were evolved. Responsibility for violation of these precepts may rest jointly upon the hospital and the radiologist, and canon applying to both parties have been enunciated by the American Medical Association. Section 7 of the "Essentials for a Registered Hospital" under which the Council on Medical Education and Hospitals approves hospitals for intern training, states, among other things, that, "It shall not be the policy of the hospital to make a profit from the department of radiology." Section 4, Article VI, of the "Principles of Medical Ethics" states, "It is unprofessional for a physician to dispose of his

professional attainments or services to any lay body, organization, group or individual, by whatever name called, or however organized, under terms or conditions which permit a direct profit from the fees, salary or compensation received to accrue to the lay body or individual employing him. Such a procedure is beneath the dignity of professional practice, is unfair competition with the profession at large, is harmful alike to the profession of medicine and the welfare of the people, and is against sound public policy." It is to be emphasized that the question involved is not one of financial gain, it is the question of who shall control, guide and develop the specialty of radiology.

As stated in the Manual referred to above, it is possible for a radiologist to conform with these principles under a salary or a percentage agreement. It has come to be generally recognized, however, that a rental or fee basis under which the hospital is reimbursed by the physician, instead of vice versa, is the sounder and more logical plan in the majority of cases. Specific recommendations for drawing up a rental agreement will be found in the Manual, in the Yearbook of Radiology, 1934, page 289, and in The American Journal of Roentgenology and Radium Therapy for January, 1939, page 126.

Many leading hospitals employ a radiologist on a salary basis and many have percentage arrangements. In some of these institutions the agreement is satisfactory to both the hospital and the radiologist. The beginning practitioner, however, will hear many stories from his older colleagues of highly competent radiologists who helped to build up an outstanding hospital roentgen-ray department while working on a salary basis, only to be replaced by one who was willing to accept a lower salary or commission when the hospital board of trustees found it desirable to supplement regular income with a profit from the radiological department. The young radiologist accepting a hospital appointment will serve himself, his specialty and his patients by requesting that he be permitted to practice in the hospital on a fee-for-service basis the same as other members of the staff.

Some Harmful Influences

A proper financial arrangement will usually avoid other problems which sometimes arise in the radiologist's relations with his hospital. It must be remembered that most hospitals are controlled and administered by laymen and the physician must be prepared to encounter certain tendencies and attitudes arising from this fact. During the growth of hospital insurance plans in recent years there has been a concerted effort on the part of some groups to define radiological services as a part of hospital care and to include the radiologist's services as benefits of the insurance contract. The proposal has been made, and in a few institutions it is a practice, to include radiological services as a part of the routine care of the hospital at an all-inclusive per diem rate. In a few localities attempts have been made to divide radiology into technical and professional phases with two charges, one for the "technical" service involved in producing the film and the other for the "professional" service of making an interpretation.

To a doctor who presumably is familiar with the fundamental precepts of his profession and cognizant of the profound importance of the personal equation in the application of medical science, there should be no necessity for pointing out the manifest evils created by such systems of practice. The beginning radiologist should be informed concerning these problems and he should be prepared to reveal objectively their harmful influences to the profession and to the public.

Advice to Laertes

Science nor pedagogy has not as yet discovered any substitute for experience as an imparter of knowledge. The young radiologist will learn much of practical value in

the early years of his practice from his associations with his colleagues and in his experience with patients. In concluding this compendium it may be worthwhile to submit a few admonitions to the radiological neophyte. If the neophyte were Laertes he would expect to hear something like the following from Polonius, an old and established radiologist:

Assuming that you have completed a prescribed course of graduate training and are eligible for examination by the American Board of Radiology, you are an accredited member of a fine and highly respected special profession. Speak of it as a profession and not as a mechanical procedure. Your clients are patients, not cases. Your office is an office and not a laboratory. In the hospital you work in a department, not a laboratory. You make examinations and render diagnoses; you do not take pictures or read films. In the case of therapy, of course, you treat the sick.

Perhaps you will accept a full time hospital appointment when you begin practice, or you may open a private office. If the latter, you will send out a dignified announcement to physicians in the neighborhood notifying them that your services are available to their patients upon referral. On your office door you should announce yourself as a physician, M.D., with perhaps an additional single word, "Radiology," or "Roentgenology." Anything further is unnecessary and may be regarded as in bad taste. You should never, of course, advertise yourself or your office in a lay publication.

You should avoid publicity with the full knowledge that aggrandizing reports in the press usually impart a harmfully distorted notion to the average laymen and subjects you to critical mistrust by your fellow physicians.

The very first thing you should do upon beginning your practice is to become a member of your county medical society. As a practicing physician you must assume your share of the responsibilities resting upon the organized profession and you must take an active part in the work of your local medical society. You should affiliate with the local radiological society if one exists, and you should apply for membership in at least one of the national radiological societies. As a member of the national radiological societies and of organized medicine, you should contribute to the scientific and socio-economic activities which these societies encompass.

Assume your proper place in the civic life of your community, not because it is "good business," but in order that the profession of medicine may occupy its rightful rôle in community activities.

Radiology is a stern mistress; you must keep abreast of progress not only in your own specialty but in other medical and surgical fields. You should attend state and national society meetings whenever possible.

Never permit yourself to become a "film reader." Conduct yourself as a doctor, not as an "x-ray man." Give personal attention to every patient referred to you for examination, else you deny him the complete benefits of the art you practice.

NEW MEMBERS

At the annual meeting of the American Roentgen Ray Society held in Chicago, Illinois, September 19–22, 1939, the following were elected to membership:

Honorary Membership: Dr. Med. Hans R. Schinz, Zurich, Switzerland, Professor of Radiology, University of Zurich; President of the Fourth International Congress of Radiology; Dr. Med. Hermann Holthusen, Hamburg, Germany, Professor of Radiology, University of Hamburg, President-Elect of the Sixth International Congress of Radiology.

Active Membership: Dr. Ralph Bacon, Erie, Pennsylvania; Dr. John S. Bouslog, Denver, Colorado; Dr. Dawson A. Dowell, Omaha, Nebraska; Dr. Louis Edeiken, Philadelphia, Pennsylvania; Dr. Glenn R. Ford, Endicott, New York; Dr. Wendell C. Hall, Hartford, Connecticut; Dr. Thomas A. Hartgraves, Phoenix, Arizona;

Dr. William S. Judy, Greenville, South Carolina; Dr. Patrick H. Malcolmson, Edmonton, Alberta; Lieutenant Colonel William W. McCaw, M.C., U.S.A., Panama Canal Zone; Dr. Harold C. Ochsner, Indianapolis, Indiana; Dr. Lester W. Paul, Madison, Wisconsin; Dr. W. A. Quimby, Wheeling, West Virginia; Dr. Jack Spencer, Portland, Maine; Dr. Marcy L. Sussman, New York City; Dr. Samuel S. Steinberg, Butte, Montana; Dr. Edward L. Voke, Akron, Ohio.

Associate Membership (reinstatement):

Dr. Adolpho Kaplan, Santiago, Chile.

BIOGRAPHY OF DR. HARVEY CUSHING

Mrs. Cushing has requested me to prepare a biography of her husband and I should be most grateful to anyone who wishes to make letters, anecdotes or other memorabilia available.

Copies of all letters, no matter how brief, are desired, and if dates are omitted it is hoped that, when possible, these may be supplied (e.g., from the postmark). If original letters or other documents are submitted, they will be copied and returned promptly.

A new Medical Library building is being erected at the Yale University School of Medicine to receive Dr. Cushing's library and collections, including his letters, diaries and manuscripts. Any of his friends who wish, now or later, to present correspondence, photographs or other memorabilia for permanent preservation among the Cushing papers will receive the appreciative thanks of the University.

John F. Fulton, M.D.
Yale University School of Medicine
333 Cedar Street, New Haven, Conn.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers as space permits.

PRÉCIS DE TECHNIQUE RADIOGRAPHIQUE. Par P. Porcher, radiologiste des Hôpitaux de Paris, avec la collaboration de A. Juquelier, assistant de radiologie des Hôpitaux de Paris. Cloth. Price, 150 fr. Pp. 332, with 302 illustrations. Paris: Gauthier-Villars, 1938.

This book is a manual of roentgenological technique, profusely illustrated, showing positions for obtaining the best diagnostic detail of the various anatomical parts. The technique of roentgenoscopic examinations, when these are necessary, is described. Newer methods such as the use of the laminagraph and kymograph are not included as the author considers that these procedures have not yet become the fixed routine of all roentgenologists and are still reserved for roentgen installations in large hospitals. He does, however, include arterial encephalography according to the method of Egas Moniz of Lisbon.

In his preface he notes that technical routine is varied and all techniques are good in the hands of those who have ingeniously conceived them or have patiently worked out their details. He attempts a simplification of terminology but he also appreciates the fact that this goal, a desire for which has so often been expressed, is still far from being realized. He considers the following are most necessary for the production of a good manual of technique: the most satisfactory position and the assurance of immobility of this patient in this position; the possibility of repetition of the examination with the same exposure factors and the same quality of roentgenogram thus obtained; the effacement of extraneous shadows; the minimum of distortion and the total inclusion of the anatomical part in the roentgenogram. His book attempts to meet these requirements. Thus, when the patient's physical condition prevents total immobility during exposure, he recommends procedures to overcome this difficulty.

Some of the positions described are unusual such as the use of the "four paw" or "Mohammedan prayer" position for lateral projections of the stomach and a vertical projection for demonstration of the transverse processes of the dorsal spine. Preliminary roentgenoscopy is recommended for detection of salivary calculi. For certain examinations of the stomach and duodenum, he advises the routine use of air insufflation of the stomach through the stomach tube. In order to prevent blinding of the examiner's eyes, he employs a small electric bulb attached to the rectal tube which affords a clear vision for insertion of the tube in the dark roentgenoscopic room.

The illustrations of the various positions are clear but are of rather small size. No roentgenograms are shown to illustrate the results obtained with the various techniques. To include these would have doubled the size of the volume and for this reason the omission can hardly be considered a just criticism. This manual should be, because of its other qualities, a useful reference book.

R. S. BROMER

LE DUODÉNUM: ATLAS DE RADIOLOGIE CLINIQUE. Par P. Cottenot, Médecin radiologiste de l'Hopital Broussais, Max Lévy, Ancien chef de laboratoire à la Faculté de Médecine, et Ed. Chérigié, Assistant de radiologie de l'Hopital Broussais. Préface de M. Robineau. Cloth. Price, 285 fr. Pp. 224, with 496 illustrations. Paris: G. Doin & Cie. 1938.

The authors quote from Farabeuf the maxim that a good treatise on anatomy should consist of innumerable illustrations accompanied by a few lines of text, and they have utilized this principle in creating an excellent compendium of information about the duodenum.

This large volume of 224 pages attains a remarkable unity of purpose and is not cluttered with extraneous material or undue anatomic discussions quoted from ancient texts. The duodenum is presented as a living, changing organ in its various normal and abnormal aspects.

The need for preoperative diagnosis is stressed, as a surgeon may easily overlook by inspection and even palpation an ulcer about the existence of which he has no previous exact knowledge. Many operative cases have been

erroneously reported negative by the exploring surgeon.

Too many radiologists and many more internists who essay their own roentgen diagnoses rely wholly or too greatly on roentgenoscopy. As these authors point out, roentgenoscopy gives a probable diagnosis, roentgenography a more certain one, and the best examination must include not only careful roentgenoscopic study, but an adequate number of films made in various projections to support or deny the screen impressions.

Persistence is also a well rewarded virtue in duodenal study as subsequent search under varying conditions may reveal a crater or niche not previously demonstrable. There is little new in their technique but it is apparently painstaking and accompanied by careful observation giving unusual results.

Subjects considered in the book are, the normal duodenum, anomalies, foreign bodies, parasites, periduodenitis, stenosis, duodenitis, tumors, tuberculosis, mycosis, and ulcers. An additional and most valuable chapter includes a study of the postoperative case with recurrence at the operative site in simple excision, gastrojejunostomy and partial gastrectomy.

The quantity and excellence of the illustrations is beyond expectations for such a work. The roentgenograms, themselves unspoiled by markings, are in every case accompanied by diagrams which interpret them just as did the authors in the light of the operative and clinical findings.

This is really a remarkable collection of duodenal lesions well coördinated and described. It is well worth the time needed for careful study.

E. W. Hall

Clinical Roentgenology of the Digestive Tract. By Maurice Feldman, M.D., Assistant Professor of Gastroenterology, University of Maryland; Associate Roentgenologist, Sinai Hospital; Assistant in Gastroenterology, Mercy Hospital, Baltimore, Maryland. Cloth. Price, $10.00. Pp. 1014, with 358 illustrations. Baltimore: William Wood & Company, 1938.

In his preface, the author states that this book is intended to present a clinical roentgenological consideration of diseases of the gastrointestinal tract and thus it is written especially as an aid to the roentgenologist, gastroenterologist, student and general practitioner. All phases of roentgenologic diagnosis of abnormalities of the gastrointestinal tract are covered. The clinical aspects of each subject are also given consideration which in some instances seem too comprehensive to be included in a volume intended primarily as a work on roentgenology.

The text is arranged in 10 divisions, as follows: Esophagus, Stomach, Duodenum, Small Intestines, Colon, Hernia, Appendix, Gall Bladder, Pancreas and Miscellaneous. An enormous amount of work was done in selecting material from the literature for presentation in the text. In addition, 179 tabulations of the reports of other authors are included. These tabulations are a valuable and interesting feature of the book.

A few errors in spelling and grammar are noted but these, together with an occasional inaccuracy in the extensive bibliography, are unimportant as far as the general value of the book is concerned. The volume will serve as a text and reference book for anyone concerned with the diagnosis of diseases of the gastrointestinal tract.

J. P. Medelman

Röntgendiagnostik der Gelenke mittels Doppelkontrastmethode. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, Ergänzungsband 56.) Von Dr. J. Oberholzer, Chefarzt am kantonalen Krankenhaus Wallenstadt, früher Oberarzt der chirurgischen Abteilung Kantonsspital Aarau/Schweiz. Mit Vorwort von Dr. Med. E. Bircher, A. Spitaldirektor Aarau. Paper, RM. 23.-; bound, RM. 25.- Pp. 128, with 134 illustrations. Leipzig: Georg Thieme, 1938.

This monograph is a report of studies carried out during a period of eight years in Switzerland using the injection of air and uroselectan into joints in over 2,000 cases. The use of air injections into the knee joint goes back to 1906 and has been recommended periodically by various workers since then. Iodized oil was used in 1930 and various preparations have been employed by different workers in numerous publications. Bircher, director of the hospital in which this work was carried out, conceived the idea of using both positive and negative contrast substances to obtain more accurate delineation of the internal structure of the knee.

The technique consists in the puncture of the joint under aseptic precautions with a short, thick, double barreled needle, aspiration of the exudate, and injection of oxygen or air through a thin insufflation cannula under controlled pressure up to 150 mm. of water. In people over fifty it is preferable not to exceed 120 mm.; pressure over 200 mm. may lead to tears in the capsule. The gas injection is followed by the injection of 2–3 cc. of perabrodil, an organic iodine preparation commonly used for intravenous pyelography. Injections should be made on the side of the knee away from the suspected injury and under local anesthesia to avoid muscle spasm. Roentgen exposures should be made with minimal moving of the patient in anteroposterior, oblique and lateral projections with the needle in place.

The alleged dangers of air embolism have not materialized in the author's large experience. Para-articular air injection handicaps the study, but is not otherwise harmful.

Detailed and illuminating descriptions are given of the appearance of the normal knee joint in various projections with numerous excellent illustrations. Information may be obtained not only regarding the menisci, but also the cruciate ligaments, Hoffa's fat body, and the outlines of the joint capsule. The fabella always lies outside of the air containing space and is thus readily distinguishable from a loose body within the joint.

Gross deformities, lesions, tears, and subluxations of the menisci are demonstrable by this method of pneumoroentgenography, although the exact location is not always so readily determined. Various types of lesions all confirmed by operation are illustrated by numerous case reports and roentgen reproductions. Early diagnosis may lead to an early operation which might otherwise be postponed until conservative measures had been tried and much time lost. Studies were made in 55 cases following excision of the meniscus and in most there was some attempt at regeneration. Complete regeneration, usually in younger individuals, is reported in 16 cases.

Severe internal injuries of the knee often have lesions of the collateral and cruciate ligaments associated with the meniscus lesion. Tears of the cruciate ligaments may be recognized by a sprain type injury at one of the tibial spines. The value of pneumoroentgenography is in ruling out an associated meniscus lesion, although the actual lesion of the cruciate ligament may sometimes be seen. Lesions of the collateral ligaments and tears in the articular capsule may also be recognized by the extravasation of the injected gas into the periarticular tissues. Old capsular injuries are shown by the Pellegrini-Stieda calcium deposits.

Occasionally pneumoroentgenography may yield valuable information and understanding in cases of traumatic loose bodies within the joint, osteochondritis dissecans, chondropathia of the patella, and in many cases of cartilage degeneration in arthritis.

The author has made and reported similar studies on the elbow, shoulder and hip joints, but here the anatomical structures are simpler and the occasion for such study is less frequent and the findings correspondingly less informative. In the elbow an identification of loose bodies within the joint capsule may be made and an estimate may be gained of the capsule itself. Studies of the shoulder reveal the state of the capsule in cases prone to dislocation and indicate the site for plastic repair. Special precautions should be made in studies on the hip joint and the injection should be controlled with roentgenoscopic observation. The normal findings are reported and also the appearance obtained in several cases of Perthes' disease and of degenerative arthritis.

One gains the impression from this monograph that the author has introduced a valuable method particularly for the study of the knee joint. If the method is to be used profitably, however, it should be used frequently in a large clinic where many observations can be made and skill acquired in technique and interpretations. Under such a plan, the numerous fine illustrations which the author provides would serve as an excellent reference atlas. Sporadic and half-hearted attempts with the method seem doomed to failure.

William A. Evans, Jr.

BOOKS RECEIVED

Cancer of the Colon and Rectum: Its Diagnosis and Treatment. By Fred W. Rankin, B.A., M.D., Sc.D., F.A.C.S., Surgeon, St. Joseph's and Good Samaritan Hospitals, Lexington, Kentucky, and A. Stephens Graham, M.D., M.S. (in Surgery), F.A.C.S., Surgeon, Stuart Circle Hospital, Richmond, Virginia; Assistant Professor of Surgery, Medical College of Virginia. Cloth.

Price, $5.50. Pp. 358, with 133 illustrations. Springfield, Illinois: Charles C Thomas, 1939.

Tumors of the Skin, Benign and Malignant. By Joseph Jordan Eller, M.D., Attending Dermatologist, City Hospital, New York City; Consulting Dermatologist: French Hospital, Broad Street Hospital, New York, etc. Cloth. Price, $10.00. Pp. 607, with 401 illustrations. Philadelphia: Lea & Febiger, 1939.

Gastrointestinal Dysfunction. By Barton Arthur Rhinehart, A.B. (Zoology), M.D. Cum Laude (Indiana) A.O.A., Associate Professor of Roentgenology, University of Arkansas School of Medicine; Consulting Roentgenologist to St. Vincent's Infirmary, Arkansas Baptist Hospital, and Arkansas Children's Hospital, etc. Cloth. Price, $6.00. Pp. 311, with 48 plates. Little Rock, Arkansas: Central Printing Co., 1939.

Roentgen Technique. By Clyde McNeill, M.D. Cloth. Price, $5.00. Pp. 315, with 268 illustrations. Springfield, Illinois: Charles C Thomas, 1939.

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DEPARTMENT OF TECHNIQUE

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A ROENTGENOGRAPHIC METHOD FOR THE STUDY OF THE SECOND CERVICAL VERTEBRA*

By HAIG H. KASABACH, M.D.
NEW YORK CITY

IN 1919 George[1] described a method of making the roentgenograms of the atlas and the axis through the open mouth. This technique still remains the most informative, practical and simple procedure for routine application (Fig. 1).

Fig. 1. Anteroposterior view of the second cervical vertebra. The roentgenograms are made through the open mouth.

Ottonello[2] described a simple but ingenious method of making roentgenograms of the cervical spine in the anteroposterior view. It requires rhythmical and continuous motion of the mandible during the period of roentgenographic exposure. This results in blurring and partial disappearance of the superimposed shadow of the jaw, thereby producing a good visualization of the upper cervical segments (Fig. 2). Jacobs[3] has recently revived Ottonello's method and proposed slight modifications. He advocates the use of a rubber bag filled about two-thirds full of water

Fig. 2. The anteroposterior view of the cervical spine. Ottonello's jaw in motion method.

* From the Department of Radiology, College of Physicians and Surgeons, Columbia University, and the Presbyterian Hospital, New York.

behind the lower neck and shoulders. This will prevent overexposure of the roentgenogram in the lower cervical spine and thus produce more uniform results. He states that similar results may be obtained by using a thicker filter for the lower third and a thinner one for the upper third of the cervical spine.

In the submentovertical position the shadow of the odontoid process is projected through the foramen magnum. Unfortunately, the position is difficult and perhaps dangerous for a patient with a fracture or disease of the first or second cervical vertebrae.

On films of the skull in the oblique positions recommended for the study of the petrous bone and mastoid by Arcelin,[4] it was noted that the first and second cervical

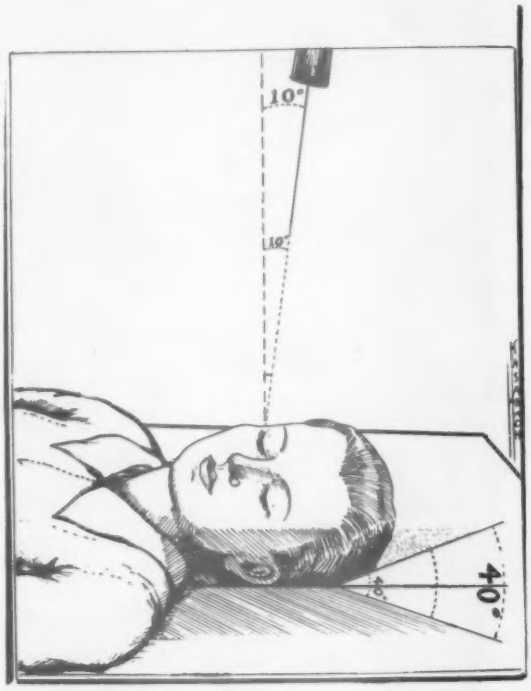

FIG. 3. The diagram of the position of the patient's head in relation to the roentgen-ray cone and the table. A roentgenogram made in this position is shown in Figure 4.

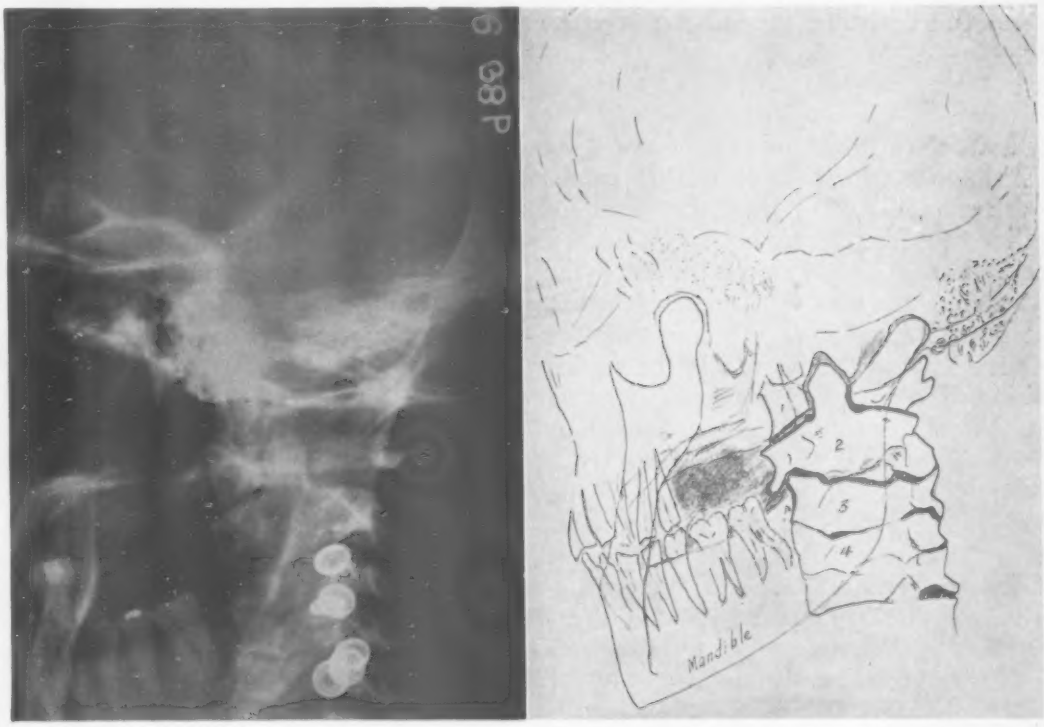

FIG. 4. Roentgenograms of the first and second cervical segments showing clearly the odontoid in the oblique projection described in the text. The position is shown diagrammatically in Figure 3.

Fig. 5. Open mouth view of the atlas showing apparent destruction of the entire odontoid process (see Fig. 6).

Fig. 6. The oblique view of the same case as in Figure 5 shows that the greater part of the odontoid process is intact. The destruction is limited to the posterolateral margin of the bone.

segments were projected free of overlying bone shadows except for part of the ramus of the mandible and that the odontoid shadow could be clearly seen. However, I found that a slight modification of the angles recommended by Arcelin produced better results as far as the odontoid was concerned. With the patient in the supine position the sagittal plane is rotated 40–45° to either side. Arcelin recommends 50° rotation, with which the odontoid is not so clearly shown in the majority of the cases. The rays are centered at a point between the external canthus of the eye and external auditory meatus. The roentgen tube is tilted 10–15° in a caudad direction (Fig. 3). For the exposure the following factors are recommended: 70–75 kv., 30 inch distance, 60 milliampere-seconds. Stereoscopic views can be obtained with the usual required shift of the roentgen tube using the Potter-Bucky diaphragm.

In the majority of cases this technical procedure seems to give a good view of the atlas and the axis (Fig. 4). By making films with the patient rotated first one way and then the other, the two projections will be at right angles to each other, which may give added information. It is inadvisable to rotate the head in the presence of a possible fracture or destructive disease of the first or second cervical vertebra. In such cases the entire body should be rotated 40–45° to the side.

This method is not recommended for routine roentgenographic studies of the cervical spine. It should be used in cases where there is some reason to suspect injury or disease in the region of the upper cervical segments. We have seen a few cases where the roentgenograms made in the anteroposterior position with the open

mouth projection seemed to show extensive bone destruction. However, the oblique views, as described above, showed the bone destruction to be limited to a smaller area* (Figs. 5 and 6).

SUMMARY

Oblique projections of the upper cervical segments are useful for the study of the atlas and the axis. They give added information in selected cases where injury or disease of either of these two segments is suspected. This method should be used in conjunction with other accepted procedures. The technique can be duplicated with reasonable accuracy.

* Recently we have made planigrams of the cervical spine, which give us an excellent section of the odontoid process, atlas and the adjoining structures. This procedure may be used as an adjunct to the other methods in selected cases.

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INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Head

de Crinis, M., and Rüsken, W. Determination and diagnostic evaluation of displacement of pineal gland shadow in the lateral roentgenogram 787

Löhr, W.: Circulatory disturbances in the brain resulting from vascular diseases and space occupying lesions as shown by arteriography 787

Loepp, W.: Pathology of the base of the skull in the roentgenogram 787

Johnson, V. C.: Value of roentgen examination of paranasal sinuses 788

Neck and Chest

Silver, H. B.: Spontaneous pneumothorax in the newborn 788

Ehrlich, D. E., and Schomer, A.: Spontaneous pneumothorax 788

Morey, J. B., and Sosman, M. C.: Spontaneous mediastinal emphysema 789

Rigler, L. G.: Density of central shadow in diagnosis of intrathoracic lesions 789

Bromer, R. S., and Wolman, I. J.: Lipoid pneumonia in infants and children 789

Platou, R. V.: Clinically manifest tuberculous pericarditis 789

Kuttner, A. G., and Reyersbach, G.: Value of special radiologic procedures in detecting cardiac enlargment in children with rheumatic heart disease 790

Reindell, H.: Heart and sport 790

Bürger, M.: Roentgenological tests of cardiac function 791

Gross, A., and Müller, P.: Roentgenologic observations in cardiac congestion of the lungs especially in chronic conditions 791

Kienböck, R.: Dissecting aneurysm of the aorta 791

Abdomen

Thelander, H. E., and Mathes, M.: Duodenal perforation in newborn infant 792

Mohr, W.: Roentgen examinations in tropical diseases of the colon 792

Gianturco, C., and Drenckhahn, C. H.: Rôle of perirenal injections of gas in radiological study of adrenal glands 792

Gynecology and Obstetrics

Philipp, E., and Huber, H.: Comparative histological and roentgenologic studies of interstitial portion of salpinx 792

Genitourinary System

Hunt, H. B., and Popma, A. M.: Excretory urography by intramuscular injection of diodrast 793

Nervous System

Maksim, G., Henthorne, J. C., and Allebach, H. K.: Neurofibromatosis with malignant thoracic tumor and metastasis in a child 793

Skeletal System

Francis, C. C.: Factors influencing appearance of centers of ossification during early childhood 794

Bade, H.: Diagnosis, differential diagnosis and therapy of Ewing's sarcoma 794

Voshell, A. F., and Taylor, K. P. A.: Regeneration of lateral condyle of humerus after excision 795

Klassen, K. P., and Curtis, G. M.: Calcium and phosphorus metabolism in ossifying fibroma of mandible 795

Hodgen, J. T., and Brennecke, F.: Osteochondroma of fibula with resultant foot drop 795

Scott, R. B.: Chondrodysplasia 796

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

de Crinis, M., and Rüsken, W. Bestimmung und diagnostosche Vertwertung der Lageveränderungen des Epiphysen- (Zirbeldrüsen-) Schattens im seitlichen Röntgenbild. (The determination and diagnostic evaluation of displacement of the pineal gland shadow in the lateral roentgenogram.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1939, *59*, 401–407.

The method of Vastine and Kinney for determining the normal position of the pineal gland has been tested in Germany and found valid by Wörner and Dyes. The method requires, however, a number of measurements and the use of charts. For this reason the authors have attempted a simplification. Measurements are made from the pineal gland to I, the porus acusticus; II, the posterior superior border of the dorsum sellae at the origin of the posterior clinoid process; and III, the tuberculum sellae. In a study of 250 skulls the normal variations were found to be 35–45 mm. (70 per cent 38–40 mm.) for I; 36–46 mm. (70 per cent 39–42 mm.) for II; and 50–62 mm. for III. Temporal lobe tumors produce no constant changes. Frontal lobe tumors increase measurement II and often decrease I. Parietal tumors decrease I and there may be either a decrease or increase of II. Tumors about the third ventricle and hypophysis increase the value of I and II, while tumors of the occipital fossa increase the value of I and decrease II. The values for I and II are normally within 2 or 3 mm. of each other. —*W. A. Evans, Jr.*

Löhr, W. Kreislaufstörungen im Gehirn, bedingt durch Gefässkrankheiten und raumbeengende Prozesse in arteriographischer Darstellung. (Circulatory disturbances in the brain resulting from vascular diseases and space occupying lesions as shown by arteriography.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1939, *59*, 474–494.

The author considers the various physiologic mechanisms governing the cerebral circulation and their effect on the appearance of the intracranial vessels following injection of the common carotid artery with thorotrast. After ligature of the external carotid artery on one side there is increased blood flow through the brain on the same side. Ordinarily the intracranial vessels are filled only on the side of the injection, but a collateral circulation to the other side can be shown when the carotid on the side opposite to the injection is ligated. Ligature of the common or internal carotid artery is dangerous in true intracranial aneurysms, but relatively harmless in arteriovenous aneurysm. When there is arteriosclerotic or syphilitic vascular disease, the circulation may be so affected that a collateral blood supply is not sufficient. Characteristic changes in the position of the vessels and in the vascularity of certain areas are seen in various intracranial tumors, hematomas, aneurysms and embolisms. Illustrative cases with excellent reproductions are provided.—*W. A. Evans, Jr.*

Loepp, W. Die Pathologie der Schädelbasis im Röntgenbild. (The pathology of the base of the skull in the roentgenogram.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1939, *59*, 451–474.

This report is based on the findings obtained when the skull is examined with the patient lying on his back with the neck hyperextended and the ray directed under the arch of the mandible. This view shows chiefly the floor of the middle fossa and such structures as the sphenoid bone and its greater wings, the pterygoid process, the petrous pyramids, the foramen ovale and spinosum, the jugular and lacerum foramina, and both ends of the carotid canal. The complexity of the structures and variation from individual to individual requires great experience for the recognition of pathological changes. The numerous illustrations provide examples of leontiasis, acromegaly, arterial calcification, hypophyseal tumors, fractures, petrositis, syphilitic osteomyelitis, sarcoma, meningiomas and various other tumors both primary and metastatic occurring in this area. —*W. A. Evans, Jr.*

Johnson, Vincent C. The value of roentgen examination of the paranasal sinuses. *Radiology*, March, 1939, *32*, 303–310.

A statistical review was made of all the roentgen examinations of the sinuses made at the University Hospital during the two year period ending June 30, 1936. These examinations made up 1.8 per cent of all the diagnostic procedures conducted by the department. From this review the author concludes that the roentgen examination of the sinus is not necessary to recognize disease. Its value is in determining the location and extent of the lesion involving the sinuses, as well as in the matter of adding leading information as to the nature of the disease process known to exist. Thus the roentgenographic approach to the diagnosis of paranasal sinus disease offers convincing proof that such methods are reliable if the limitations of the procedure are clearly appreciated. In few instances can the changes found in the film be interpreted in terms of accurate pathology. For example, a dense clouding of an antrum may be due to greatly thickened mucous membrane, thick purulent material or whole blood. Minimal changes due to disease processes, occurring particularly in the ethmoid and sphenoid cells, may be overlooked because these structures are disadvantageously situated for perfect visualization under some circumstances. The author concludes that accurate interpretation of sinus roentgenograms is a painstaking, even difficult task, although the pathological signs characteristic of disease are relatively few.—*J. H. Harris.*

NECK AND CHEST

Silver, Harry B. Spontaneous pneumothorax in the newborn. *Am. J. Dis. Child.*, April, 1939, *57*, 907–915.

Silver reviewed the literature and found 5 reported cases of spontaneous penumothorax in the newborn and added 1 case of his own. He believes that the term spontaneous pneumothorax in the newborn should be restricted to cases in which a ball valve type of obstruction occurring at the onset of respiration causes emphysema which is followed by rupture of the lung and pneumothorax. He is able to present, he believes, for the first time roentgen evidence of the occurrence of both of these stages. In his first roentgenogram he shows emphysema of the affected side and in the second, the spontaneous pneumothorax is shown resulting in compression collapse with rupture of the lung. —*R. S. Bromer.*

Ehrlich, David E., and Schomer, Alexander. Spontaneous pneumothorax. *Radiology*, April, 1938, *30*, 471–484.

Three types of pneumothorax are described:

The open type in which the air enters and leaves the pleural cavity through the point of rupture in the lung during inspiration and expiration, respectively. An amount of air sufficient to overcome the negative pressure is thus introduced; the lung collapses and the quantity of air in the pleural cavity remains stationary until slow absorption commences, whereupon the tear in the lung and pleura heals.

The closed type in which the point of rupture in the lung becomes sealed quickly. The amount of air thus admitted into the pleural cavity before closure of the tear is variable, depending upon the size of the rupture and the amount of positive pressure necessary to cause sufficient lung collapse to admit such closure.

In the valvular type, entrance but no exit of air into the pleural cavity is permitted. Air thus continues to accumulate, being sucked in with every inspiration and affords no means of exit during expiration.

The etiology is divided into primary, essential or idiopathic spontaneous pneumothorax which occurs in healthy individuals and for which the cause if any, is difficult to find and impossible to prove. Secondary spontaneous pneumothorax develops as a result of tuberculosis of the lungs or of the pleura or it may develop following any type of pathology involving the lungs or mediastinum.

Among the theories as to the formation of pneumothorax are:

1. Rupture of a pleural tuberculous focus.
2. Rupture of a pleural adhesion.
3. Rupture of an air bubble resulting from emphysematous vesicles or bullae.
4. The authors' theory which depends upon the presence of a pleural defect and which permits the escape of air during the natural wear and tear.

The diagnosis is to be considered with the history of a sudden onset of sharp pain accompanied by increased dyspnea; however, conclusive diagnosis can be made only by roentgen examination.

Treatment requires only rest and sympto-

matic medication unless there is severe and progressive dyspnea, for which deflation is necessary.

The author gives case reports and illustrations of different types of pneumothorax.—*J. H. Harris.*

Morey, John B., and Sosman, Merrill C. Spontaneous mediastinal emphysema, with report of a case associated with spontaneous pneumothorax. *Radiology*, Jan., 1939, *32*, 19–22.

The authors report a case of spontaneous mediastinal pneumothorax. The sudden onset, the retrosternal pain, the dyspnea and even cyanosis and the radiation of the pain to the shoulder and arm, strongly suggest the diagnosis of coronary disease. However, the patient has not the severe collapse seen in thrombosis of the coronary artery. The most characteristic finding is the noise heard in the chest. It is a peculiar knock or click and at times resembles the squeak of a leather saddle. It may be synchronous with the heart beat, respiration or both.

Roentgen examination will shown pneumothorax if present and at times it shows air along the lateral borders of the mediastinum and heart. The condition is rather benign but may recur. Most cases clear up with rest, sedatives and time.—*J. H. Harris.*

Rigler, Leo G. The density of the central shadow in the diagnosis of intrathoracic lesions. *Radiology*, March, 1939, *32*, 316–324.

Attention is called to the value of the variation in density of the cardiac shadow as an aid in making a diagnosis of disease in the parts of the lungs located behind the heart when viewed in the anteroposterior projection.

For such diagnosis the chest film must be slightly overexposed. As the density of the normal heart shadow above the diaphragm should be uniform on both sides of the spine, any variation in this density has significance in terms of disease. Bedside examinations for early pneumonia are made at short focal distance and hence the cardiac shadow is exaggerated. In such cases a consolidation could be well hidden by the heart shadow, but if the proper penetration is used the additional consolidation in the lung tissue will make a distinct difference in the density of the two halves of the cardiac shadow and hence lead to a correct diagnosis.

Lesions other than pneumonia will cause such variations in cardiac density, among which are certain unusual types of bronchiectasis, massive atelectasis and localized collections of fluid. Naturally, the history and physical findings must be correlated with the roentgen findings in arriving at a diagnosis.—*J. H. Harris.*

Bromer, Ralph S., and Wolman, Irving J. Lipoid pneumonia in infants and children. *Radiology*, Jan., 1939, *32*, 1–7.

The authors conclusions are:

Pneumonia due to the aspiration of oily substances is not uncommon and can be considered a clinical and pathologic entity.

Infants with physical debility and neurologic disorders seem to be unusually susceptible.

The roentgen diagnosis can be made in patients having extensive involvement. It is based upon location of lesions in the perihilar regions, in the posterior portions of the lungs, and to a greater degree in the right lung than in the left. In the moderate and mild cases, serial roentgenograms and an accurate history are needed before a positive diagnosis can be attempted. The necessity for serial examinations cannot be emphasized too strongly.

It is not wise to employ liquid petrolatum, etc., as nose drops in any small, weak, or debilitated child. When infants are inclined to vomit oil it is important that they be placed on the side or abdomen rather than upon the back. Cod-liver oil or liquid petrolatum should never be forced.—*J. H. Harris.*

Platou, Ralph V. Clinically manifest tuberculous pericarditis. *Am. J. Dis. Child.*, June, 1939, *57*, 1386–1397.

Tuberculosis of the pericardium is not an unusual observation at necropsy, particularly in cases of advanced disseminated tuberculosis; but the presence of clinically manifest, or clinically primary, tuberculous pericarditis is unusual in adults and rare in children. Platou reports a case of clinically primary tuberculous pericarditis in a ten year old Negro boy. Determinations of venous pressure, of intrapericardial pressure and circulation times were made. The introduction of air in some cases seems to have retarded the rate of reaccumulation of

the pericardial exudate. The use of this mode of therapy in his patient afforded the opportunity to record some of the effects produced by changes in pressure around the heart. He noted increasing rapidity of fall in the intrapericardial pressures with successive paracenteses. A chart illustrates the persistent tachycardia and fever, slowly declining systolic blood pressure and pulse pressure, decrease in the rate of erythrocyte sedimentation and relation of the venous and the pericardial pressure. The paper contains roentgenograms showing the pericardial effusion, increased width of the heart shadow, etc., the result of pneumopericardium and the decrease in size of the cardiac shadow after paracentesis.—*R. S. Bromer.*

Kuttner, Ann G., and Reyersbach, Gertrude. The value of special radiologic procedures in detecting cardiac enlargement in children with rheumatic heart disease. *Am. Heart J.*, August, 1939, *18*, 213–227.

The authors emphasize the importance of Wilson's procedure in recognizing early cardiac enlargement. This consists in observing the amount of rotation in the left anterior oblique direction necessary to have the posterior border of the left ventricle pass away from the spine. A greater angle of rotation indicates greater left ventricular enlargement. Wilson established 55 degrees as the upper normal range.

Fifty-five children, eight to fifteen years of age, having apical systolic murmurs, were studied by means of Wilson's method using a turntable, by physical examination, and by a frontal teleroentgenogram. Children with clinical or laboratory evidence of rheumatic activity were excluded. For control, a group of 101 healthy girls seven to fifteen years of age was studied.

In the control group 77 per cent had an angle of clearance of less than 55 degrees, in 22 per cent the angle was 55 degrees.

In the rheumatic group only 7 exhibited cardiac enlargement on physical examination and all of these showed an angle of clearance well above 55 degrees, although only 4 had an enlarged frontal area on the teleroentgenogram. Of the remaining children 37, or 77 per cent, showed an angle of clearance of 55 degrees or more; however, only 11 were definitely abnormal with angles of 60 degrees or more.

A group of 8 children with apical systolic and diastolic murmurs was studied with reference to the detection of left auricular enlargement by means of the barium filled esophagus, and in 5 the enlargement was demonstrable, although only 2 showed increased measurements of the frontal area.

A single roentgen observation is not as significant as a series in determining questionable cardiac enlargement. Measurements of the frontal area are of little value in early rheumatic heart disease. The angle of clearance is a valuable aid in detecting early left ventricular enlargement. An enlarged left auricle associated with mitral stenosis is best shown by posterior displacement of the barium filled esophagus. Mitral stenosis may be present, however, in the absence of this sign.—*W. A. Evans, Jr.*

Reindell, H. Herz and Sport: Unsere heutige Einstellung zur Beurteilung der Herzgrösse und zur Frage der Schädigung. (Heart and sport—Our present-day attitude to the estimation of the size of the heart and to the question of damage.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1939, *60*, 35–44.

Moritz and Dietlen have shown the close relationship between the muscle mass of the body and that of the heart. Orthodiagraphic studies on athletes have frequently revealed cardiac enlargement and there has been much discussion as to whether this is pathologic or physiologic. The author's studies over a period of years have indicated that these may be purely physiological and temporary cardiac enlargement associated with the demands of increased performance. The present material comprises kymographic and electrocardiographic studies on more than 700 competitive athletes of different ages. After five years of athletic activity the heart becomes larger and broader. If the activity is of short duration, the enlargement is toward the left; if of long duration, toward the right. The same changes occur in both the relatively young and old. The largest hearts are seen in cyclers, boxers, and runners of the steeple chase. The question commonly comes up as to whether the enlargement is due to dilatation or hypertrophy of the muscle. This was answered in a long distance skier who was killed shortly after cardiac studies had been made. In this instance there were both hypertrophy and dilatation. Among a group of athletes there is a higher incidence of kymographic Type II (Stumpf) cardiac pulsation; i.e., there is a tendency to diminution in

the relative amplitude of the pulsation at the cardiac apex, and in some instances there is an almost complete absence of pulsation in this area.—*W. A. Evans, Jr.*

Bürger, M. Röntgenologische Herzfunktionsprüfung. (Roentgenological tests of cardiac function.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1939, *60*, 78–92.

Tests of cardiac function should preferably be termed tests of the circulation inasmuch as the heart alone is not involved, but also the entire regulating mechanism. The size of the heart is essentially an indication of its state of filling. The author reviews the variations of respiration, pulse rate, etc., which may influence the size of the heart. The effects of increased and decreased intrathoracic pressure, the Valsalva and Müller tests respectively, on the size of the heart result not only from the increased pressure, but also from reflex changes involving the blood pressure and pulse rate. Proper interpretation requires consideration of the entire circulation. The first roentgen studies of this sort were reported by v. Criegern in 1899. The Valsalva test, which is an accompaniment of all heavy exercise, leads to an accumulation of venous blood and distention of the large veins. The pressure in the antecubital vein may reach 500 mm. and the intracranial pressure 1,000 mm. of water. The decrease in the size of the heart is due to the obstruction of blood flow into the superior vena cava.

The author has devised a standard method for carrying out the Valsalva test and for measuring the changes in surface area of the heart on the orthodiagram. In a group of adolescents it was found that a group of large hearts showed an average decrease of 15.3 per cent in surface area during the test while the decrease was 8.5 per cent in the small hearts. In adults the conditions were otherwise; the average decrease in size was 13–14 per cent when the intrapulmonary pressure was increased 40–50 mm. Hg for five seconds, the decrease being 10 per cent in athletes with large well rounded left ventricles, and 25 per cent in hypoplastic ptotic type hearts. Kymographic studies showed that during the test all segments of the heart decreased in size at the same time. The blood pressure fell markedly in those with asthenic type hearts, slightly in normal hearts, and in athletes there was a definite rise in the arterial blood pressure during the test. Observations of the capillaries revealed a slowing of the blood flow during the test followed by an acceleration. Electrocardiographic studies during the test showed extrasystoles, conduction disturbances, and variation of the pacemaker in one-fifth of the cases. In one instance the test was followed by cardiac standstill lasting 4.8 seconds.—*W. A. Evans, Jr.*

Gross, Arthur, and Müller, Peter. Röntgenologische Beobachtungen bei kardialen Stauungslungen, insbesondere bei chronischen Zuständen. (Roentgenologic observations in cardiac congestion of the lungs especially in chronic conditions.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1939, *59*, 428–439.

The authors describe two types of vascular markings in the hilar areas of the lungs, the tree and the shrub types. Observations of these markings give a reliable estimate of the functional capacity of the heart. The size and shape of the heart are to be observed for the type of cardiac disease rather than the degree of functional insufficiency which is best shown by the lung fields. In the tree type of markings, the signs of congestion are apt to appear late and to be minimal, while the converse is true of patients with the shrub type. In acute failure there may be either a diffuse clouding of the lung fields or a focal type of clouding particularly in the hilar areas and in the middle and lower lung fields. Chronic passive congestion results in hemosiderin deposits and connective tissue organization which appear as dense nodules in the middle and lower lung fields, and over a period of years these may be converted into bone. The manifestation of congestion always occurs in the same way in the same individual, indicating that there is an individual anatomical basis for these individually characteristic appearances.—*W. A. Evans, Jr.*

Kienböck, R. Ueber das dissezierende Aneurysma der Aorta. (Dissecting aneurysm of the aorta.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1939, *59*, 494–503.

The differentiation of aortic aneurysm, mediastinal tumor, and pulmonary tumor is often difficult. The diagnosis of dissecting aneurysm is even more difficult and until recently had not been made during life either clinically or roentgenologically. Five cases are presented in which this diagnosis was made roentgenologically.

The first one was published in 1931. The recognition of the dissecting character of the aneurysm seems to depend on the recognition of a part of the aortic wall within the aneurysmal mass or on a sudden change in the form of an aneurysm which has been under observation. None of the case reports contain mention of confirmation of the diagnosis by microscopy.—*W. A. Evans, Jr.*

ABDOMEN

THELANDER, H. E., and MATHES, MARY. Duodenal perforation in a newborn infant. *Am. J. Dis. Child.*, March, 1939, *57*, 596–602.

The authors made a diagnosis of duodenal perforation in an infant, one day old. She was operated upon and treated with sulfanilamide but died on the tenth postoperative day with sepsis due to *B. coli*, empyema and bronchial fistula, the gastrointestinal tract functioning normally after the repair up to the time of death. In gastrointestinal symptoms of newborn babies indicating obstruction, the authors recommend roentgen study after the ingestion of barium sulfate. This should be done early to facilitate the diagnosis of the type and the situation of the lesion. In their patient, the roentgen examination showed pneumoperitoneum and the escape of barium sulfate to the right flank.

They advocate surgical intervention in case of perforation if the condition of the child warrants it. Even with the lack of the usual symptoms and reactions of infection, sepsis should be suspected. The peritoneal contents should always be cultured, and blood cultures should be made more frequently than is the custom at present. Sulfanilamide was well tolerated by their patient and should be used, they believe, if the organism found is susceptible to the drug. Transfusion is also recommended.—*R. S. Bromer.*

MOHR, WERNER. Röntgenuntersuchungen bei tropischen Dickdarmerkrankungen. (Roentgen examinations in tropical diseases of the colon.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1939, *60*, 14–35.

This publication is based on the varied and abundant material of the Institute for Tropical Diseases at Hamburg. Studied by barium enema were 57 cases of amebic dysentery in active and inactive stages, 13 cases of bacillary dysentery, 44 cases of colitis of indeterminate etiology, 17 cases of mucous colitis, 4 cases of schistosomiasis, 3 of lambliasis, 10 of sprue, and 1 of balantidiasis. It is the author's opinion that there is no characteristic appearance for any of the specific colitides and that they do not differ from each other or from nonspecific colitis in the roentgen findings. The roentgen examination is, however, of value and importance in determining the location, extent, and severity of the lesions.—*W. A. Evans, Jr.*

GIANTURCO, CESARE, and DRENCKHAHN, C. H. The rôle of perirenal injections of gas in the radiological study of the adrenal glands. *Radiology*, April, 1938, *30*, 500–504.

The authors give in detail the technique for injection of gas in the perirenal space as an aid in the diagnosis of adrenal gland tumors. They give the reports of 2 cases in which this procedure was done.

As this is a technique article, it cannot be abstracted in a few paragraphs and those interested should read the entire article.—*J. H. Harris.*

GYNECOLOGY AND OBSTETRICS

PHILIPP, E., and HUBER, H. Vergleichende histologische und röntgenologische Untersuchungen über den interstitiellen Tubenabschnitt. (Comparative histological and roentgenologic studies of the interstitial portion of the salpinx.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1939, *60*, 1–14.

These studies are concerned chiefly with the causes of tubal obstructions as demonstrated by salpingography. Obstructions may occur by kinking of otherwise normal tubes in marked degrees of anteversion or retroversion of the uterus. The position of a tube may also be so distorted by a uterine tumor as to be obstructed. In true obstructions, inflammation plays a very secondary rôle to endometriosis in the experience of the authors as a cause of obstruction. The roentgen findings in inflammation are often uncharacteristic; only rarely is complete obstruction observed and as a rule the changes are most pronounced in the lateral ends of the tubes. Endometriosis produces obstruction in the interstitial part of the tube and is often confined to this part. Sterility is the most important clinical result of endometriosis

and this occurs in three ways. The salpingeal endometriosis may extend to the peritoneal cavity causing complete obstruction of the tube with endometrial polyps. Many causes of sterility after the age of thirty-five (senile sterility) are due to a limited endometrial proliferation into the interstitial part of the tube. The salpingographic picture in these cases is characteristic in the sharp pointed appearance at the openings of the tubes. Myomas may produce sterility through direct obstruction, but the more common cause is an associated endometriosis. In the authors' group of 162 myomas, 54.9 per cent exhibited a tubal endometriosis and in 29 per cent there was complete bilateral tubal obstruction. If a myoma is to be removed to correct sterility, the patency of the tubes should always be determined first.—*W. A. Evans, Jr.*

GENITOURINARY SYSTEM

Hunt, Howard B., and Popma, Alfred M. Excretory urography by the intramuscular injection of diodrast. *Radiology*, Nov., 1938, *31*, 587–594.

The well established benefits of excretory urography may be extended by making the procedure available in cases in which intravenous administration is difficult or impractical, such as in infants and children, or in adults with buried or blocked veins.

For intramuscular administration, the authors use diodrast (Winthrop), a 35 per cent solution of iopyracil. Ten to 20 cc. is used in children and 20 to 30 cc. in adults, giving one-half the dosage in each buttock. Novocain without adrenalin is given with the diodrast in some cases. Structural details are usually best shown in thirty to forty minutes.

The method of administration of the opaque solution has been used in 18 cases, 10 of whom were children, and the authors were able to obtain films of diagnostic significance. There were no clinical evidences of injury at the site of injection.—*J. H. Harris.*

NERVOUS SYSTEM

Maksim, G., Henthorne, J. C., and Allebach, H. K. Neurofibromatosis with malignant thoracic tumor and metastasis in a child. *Am. J. Dis. Child.*, Feb., 1939, *57*, 381–390.

Generalized neurofibromatosis is a relatively rare condition, and its occurrence in children in a fully developed and clinically recognizable form is even more rare. Neurofibromatosis, or Recklinghausen's disease, is to be distinguished both from solitary neurofibroma, a condition which is found frequently, and from fibrocystic disease of the bone (hyperparathyroid disease), which also bears Recklinghausen's name.

A classification based on the clinical characteristics of the disease is as follows:

Incomplete Form (*Forme Fruste*). This form of neurofibromatosis consists in patches of brown pigmentation (café au lait spots) on the skin of the body and on exposed surfaces and is the type most commonly found in children. These pigmented patches may precede by years the development of other manifestations of the disease.

Multiple Neurofibromas. Under this heading may be grouped those cases in which cutaneous and subcutaneous tumors arise from the skin, from subcutaneous tissues or from any of the peripheral nerves. In addition, there may be included those cases in which tumors arise from the sympathetic, the spinal or the cranial nerves.

Neurofibromatosis with Osseous Changes. A classification of osseous changes as being part of the picture of neurofibromatosis was first given by Brooks and Lehman. These osseous changes include (1) scoliosis, (2) abnormalities in growth and (3) subperiosteal cysts. Weber and Perdrau later further enlarged on the subject of changes in bone and discussed "periosteal neurofibromatosis."

Elephantiasis Neuromatosa. This form of the disease consists of an unsightly prominent overgrowth of the skin and the subcutaneous tissues, most frequently about the scalp and head, although it may involve any part of the body. It is usually an advanced form of the disease and hence is found chiefly in adults.

The authors report a case of a girl of twelve years who was referred for treatment with a diagnosis of intrathoracic tumor. The case presented many interesting features. There was no hereditary factor found and the appearance of congenital defects or anomalies was limited to a congenital convergent strabismus. The mental development as far as could be judged was normal. No definite etiologic factors were apparent, and the onset of the disease was sometime after the age of three years. Within a period of a few years the disease then developed

rapidly, so that when seen the patient already had pigmented areas, generalized neurofibromatosis and osseous changes. Areas of erosion were found on roentgen examination in the skull, on the right side of the foramen magnum and the inner table in the right parietal region. A large dense shadow filled the upper half of the thorax, left side. The tumor had displaced the trachea and the mediastinum to the right and extended up into the apex, producing supraclavicular fullness and widening of the upper intercostal spaces on the left. The left side of the diaphragm was elevated, and there was some secondary bronchiectasis at the base of the left lung. Studies of the spinal column showed enlargement of the intervertebral foramens of the first three cervical vertebrae, probably due to erosion secondary to multiple neurofibromas. There was secondary erosion of the seventh cervical and of the first and second thoracic vertebrae on the left side, as a result of pressure of the tumor in the thorax.

The appearance of Horner's syndrome, which was evidently rather recent, was interesting; it was questionable whether it was due to involvement of the left cervical sympathetic nerves or was secondary to the malignant change in the thoracic tumor.—*R. S. Bromer.*

SKELETAL SYSTEM

Francis, Carl C. Factors influencing appearance of centers of ossification during early childhood. *Am. J. Dis. Child.*, April, 1939, *57*, 817–830.

Author's summary:

1. There is a definite sequence as well as date of appearance for centers of ossification, but this schedule may be interrupted or retarded by metabolic or constitutional disturbance. Height, weight, bodily maturity and even mental expansion may show irregularities in progress.

2. Epiphysial rating is the earliest and frequently the only indicator of disturbance.

3. Progress in epiphysial rating may be used as a delicate measure of constitutional health in young children, but it will fail if employed as an indicator of bodily maturation.

4. Sick children show a lag in epiphysial rating proportionate to the duration and intensity of consitutional disturbance. When convalescence is completed the epiphysial rating advances again.

5. Epiphysial rating is influenced by available mineral and vitamin D. Children on a low mineral ration tend to lag in epiphysial rating. As a corollary of this, children growing very rapidly will tend to lag in epiphysial rating unless they are provided with ample rations of mineral and of vitamin D. When the period of rapid growth comes to a close the epiphysial rating advances rapidly.

6. Children growing slowly and given a diet rich in mineral and vitamins, particularly vitamin D, tend to advance rapidly in epiphysial rating.—*R. S. Bromer.*

Bade, Heinz. Zur Diagnose, Differentialdiagnose und Therapie des Ewing-Sarkomes. (The diagnosis, differential diagnosis and therapy of Ewing's sarcoma.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, June, 1939, *59*, 558–574.

In 1921 Ewing separated the endothelial myeloma as a special form of osteogenic sarcoma with a high degree of radiosensitivity. In France this tumor is called the reticulosarcoma of the bone marrow. The first German publications on Ewing's tumor were by Borak in 1928 and 1929. While the incidence is reported in America as being 10–15 per cent of malignant bone tumors, it certainly seems to be less common in Germany.

Pain is the outstanding clinical symptom. Fever with swelling and redness of the overlying skin often leads to a diagnosis of osteomyelitis. The joint is almost never affected. Metastases occur earlier than in osteogenic sarcoma. Over 90 per cent of the cases appear in the first three decades. The long bones are most commonly involved, usually in the diaphysis. The roentgen picture is characteristic, but not pathognomonic. There is a spindle-shaped expansion of the bone, onion skin periosteal reaction, and spicules are usually lacking. Destruction of bone occurs later and may be complete giving a *tabula rasa* appearance.

A group of 10 cases where the diagnosis without doubt was Ewing's sarcoma is reported. There were 6 children, 1 boy and 3 men ranging from one and a half to thirty-four years of age. Special features were a rather long history of pain or discomfort one to two years before the discovery of the tumor in 2 cases. In 1 patient there was a fracture in the lower third of the femoral shaft one year before the appearance of the tumor. A study of the films made at the time of the fracture revealed no evidence of

tumor and the fracture healed in a normal manner. In this group of cases a misdiagnosis of osteomyelitis was often made from the roentgen findings. Not only may pyogenic osteomyelitis resemble Ewing's sarcoma, but osseous syphilis and tuberculosis may also do so. Some cases of bone cyst, chondrosarcoma, and other bone sarcomas may closely simulate Ewing's tumor, as a number of illustrative cases indicate.

For treatment the author recommends intensive preoperative irradiation of the tumor and neighboring lymph glands, radical excision of the tumor, and then perhaps postoperative irradiation.—*W. A. Evans, Jr.*

Voshell, Allen F., and Taylor, K. P. A. Regeneration of the lateral condyle of the humerus after excision. *J. Bone & Joint Surg.*, April, 1939, *21*, 421–424.

The most common type of fracture involving the elbow in childhood is the supracondylar fracture with variations, next in frequency are the fractures of the single condyles, followed by the epiphyseal separations. When a fracture occurs, the loosened fragment assumes a displaced position consistent with the direction and amount of the fracturing force and pull of the attached muscle structures, due to the small size of the fragment, the swelling of the whole region, and the traction force exerted by the irritated muscles with resultant displacement and torsion of the loose fragment. Closed reduction is difficult and usually inaccurate and incomplete, while immobilization tion is most uncertain and frequently impossible. Hence, open reduction and internal fixation are very frequently resorted to and offer the only certain procedure for union and early immobilization. Periodically a loose fragment, perhaps a whole condyle, may be removed in its entirety with or without the epicondylar epiphysis. The natural expectation following excision of the capitellum is that the elbow would become distorted, since the ulna should tend to slide laterally into the cavity left empty by removal of this bone; this would probably cause an increase in the carrying angle and changes in the amount of motion. To expect regeneration of the lost condyle would be contrary to expectation, and has never before been reported so far as the authors could determine.

Voshell and Taylor report a case in which the lateral condyle of the humerus (capitellum) was excised, followed by complete regeneration in two years with no postural or functional deformity or disability. The roentgenograms which are reproduced show the original fracture with the operative and late results. The lateral epicondylar epiphysis was allowed to remain at operation which may account for the development of a new unit. No functional disability developed, and the only slight objective evidence of such an injury is a moderate prominence on the outer aspect of the elbow.—*R. S. Bromer.*

Klassen, Karl P., and Curtis, George M. The calcium and phosphorus metabolism in ossifying fibroma of the mandible. *J. Bone & Joint Surg.*, April, 1939, *21*, 444–450.

The authors state that reports of studies on calcium and phosphorus metabolism of patients with ossifying fibroma of the mandible could not be found on extensive search of the literature. They report a case with complete balance metabolism studies of calcium and phosphorus in a patient presenting the typical clinical and laboratory findings in this disease. The roentgenogram of the right jaw showed a multilocular cyst with expansion of the cortex. Five days before the commencement of actual balance determination, the patient was placed on a low calcium and phosphorus diet, while the water intake was maintained at a level of 1,000 cc. per day. The balance was determined over a period of nine days.

The calcium and phosphorus metabolism was found to be normal. There was no increase in the phosphatase activity of the serum.—*R. S. Bromer.*

Hodgen, John T., and Brennecke, Frances. Osteochondroma of the fibula with resultant foot drop. *J. Bone & Joint Surg.*, April, 1939, *21*, 405–408.

Benign bone tumors are noted most frequently during adolescence. These are often brought to light because of slight deformity or during roentgenographic examination. Occasionally their presence is suspected in the face of a bursitis, a stiff joint, soft tissue irritation, or actual tumor presence. Rarely do such growths demand immediate surgical intervention because of complicating nerve involvement.

The authors report 2 cases because the symptoms presented indicated progressive nerve in-

volvement with interference of locomotion. In the first patient the osteochondroma was situated on the posterior and outer aspect of the fibula, upper third. In the second it involved the inner and posterior aspect of the upper extremity of the fibula. Each patient showed a definite foot drop on physical examination. Review of the literature revealed no reported cases of foot drop subsequent to peroneal involvement in an osteochrondroma.—*R. S. Bromer.*

Scott, Roland B. Chondrodysplasia: Hereditary multiple cartilaginous exostoses. *Am. J. Dis. Child.*, May, 1939, *57*, 1075–1084.

Five cases of chondrodysplasia in a single Negro family are reported in this paper, making a total of 8 cases involving the Negro race recorded to date in the American literature. The cases illustrate the usual familial character of this disease, which shows a tendency to conform to the mendelian law of inheritance, occurring predominantly in males, in the ratio of 3:1. The family tree of the Negroes reported by Scott showed a male predominance of 5:3 in the affected members. The line of descent appears to be definitely more paternal than maternal. Characteristically, the sites of predilection for the skeletal anomalies in his patients were the metaphyses of the long bones, the costochondral junctions, the cristal borders of the pelves, the scapulas and the clavicles. The membranous bones of the face and skull were not involved.

Multiple exostoses involving various parts of the skeleton were present in each case. They are said to have a special predilection for the region of the knees, where their invariable presence may result in a genu valgum deformity. More or less dwarfing of stature, seen in each case except one, is characteristic of the disease, and it becomes more obvious as skeletal maturity is reached. The lack of growth affects the lower extremities, not the trunk, and is due to premature union of the epiphysis with the shaft. Of interest, Scott says, is the fact that enlargements at the costochondral junction (rosary) occurred in all cases. Exostoses in this location, while possibly lacking the smooth, rounded contour of the typical rachitic rosary, on superficial examination may nevertheless be confused with the true rachitic rosary in a Negro child who also presents dwarfing of stature and genu valgum deformity. Apparently such gross findings as beading of the ribs, knock knees and dwarfing may occur in cases of hereditary multiple exostoses uncomplicated by rickets.

Roentgenograms in his cases revealed the following characteristic features: (1) excessive length and width of the metaphyses due to incomplete conversion of the metaphysis into the diaphysis; (2) irregular and incomplete ossification of cartilage rests, indicated by cystic and osteoporotic areas, and (3) multiple exostoses, which formed a prominent but not a fundamental finding.

The diagnosis of chondrodysplasia is usually made without difficulty. Roentgenograms of the enchondromas in cases of this skeletal dystrophy often present soap bubble vacuolations which may roughly simulate such cystic bone diseases as benign bone cyst, giant cell tumor and Recklinghausen's osteitis fibrosa cystica. However, the history together with the physical, blood chemical and roentgen findings usually indicates the true diagnosis, which makes biopsy rarely necessary.

Some of the findings presented by the father of the children reported by Scott, namely, dwarfism, bony swellings about the epiphysial ends of the long bones, beading of the ribs, lordosis and trident hand, also commonly appear in cases of chondrodytrophia foetalis. On this basis, some authors have stressed a possible relationship between this disease and hereditary multiple exostoses. Other writers have expressed the opposing view that there is no relation between the two bone dystrophies.—*R. S. Bromer.*

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